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1939

HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

Under the joint supervision of the
UNIVERSITY OF HAWAII
and the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

1938

Issued May 1939

Published by the
UNIVERSITY OF HAWAII
Honolulu, T. H.

HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU

(Under the joint supervision of the United States Department of
Agriculture, Office of Experiment Stations, and the
University of Hawaii)

D. L. Crawford, *President, University of Hawaii*
James T. Jardine, *Chief, Office of Experiment Stations*

Station Staff as of June 30, 1938

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A. W. Burt, N. D. D. ....*Superintendent, Haleakala Branch Station*
M. L. McDougal ....*Foreman, Poamoho Farm*

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[1] In cooperation with U. S. Department of Agriculture, Bureau of Biological Survey.

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INTRODUCTION

The fiscal year 1938 was memorable in the history of the Hawaii Agricultural Experiment Station for, at the conclusion of the period, the station took its place among the experiment stations of the land-grant institutions of the states, with the same rights and privileges as accrue to such organizations.

The experiment station, while young in its new standing, had an early beginning and claims a long heritage of accomplishment in the Territory. It is a continuation of the Federal Experiment Station, established in 1901 and administered by the Office of Experiment Stations of the U. S. Department of Agriculture until 1929. This station did notable work, as evidenced by approximately 125 bulletins published. Much of this work has contributed directly to the progress of the major agricultural industries in the Territory and, in addition, has laid the foundations for development to follow.

In 1928 the Hawaii Act (45 Stat. L. 571) entitled the Territory of Hawaii to share in all benefits for agricultural research extended to the states by previous Acts of Congress, and in 1929 the Hawaii Agricultural Experiment Station was established under the auspices of the University of Hawaii. By provisions of the Act, the work of the existing Federal organization and the new Territorial station was conducted jointly and in collaboration for a period of years during which Federal support was reduced as grant funds to the station increased. At the conclusion of the fiscal year 1938 the transitional period ended, and the Federal Experiment Station established in 1901 officially passed from existence.

The Territory of Hawaii has many reasons to be deeply appreciative of the work and accomplishments of the Federal Experiment Station. We wish to take this opportunity to express this appreciation to the Office of Experiment Stations of the U. S. Department of Agriculture, and especially to Dr. James T. Jardine, Chief, under whose administration the difficult task of transferring the Federal station to the Territory was accomplished.

A. A. A. FUNDS

During the latter part of the transition period (1936-1938), great responsibilities were thrown upon the joint Federal and Territorial station by the allotment of sugar-processing-tax funds amounting to $410,000, through the Agricultural Adjustment Administration, for agricultural research along various lines, as follow: Taro investigations, liver-fluke control, rat abatement, truck-crop investigations, livestock feeds, fruit and nut investigations, and poultry. At the end of the year 1938, all such funds were expended, and accomplishments of the work are being described in station bulletins and journal articles or appear in this and earlier reports of the station. Results are also reflected in the greatly expanded experiment station staff. While personnel has, of necessity, been reduced to conform with available funds for the coming year, the technical and research men have largely been retained through increased Territorial appropriations and will carry on the more important phases of the work undertaken with the tax funds. Thus dividends will continue to accrue.

Of further benefit to the Territory has been the availability of many of these scientific workers to the University, through cooperative arrangements. Not only has research in agriculture been maintained at a high level, but also the grade of collegiate instruction in agriculture has been raised, as will be evidenced by the training and quality of students graduating from the University in future years.

Expansion and Cooperation

During the transition period from 1929 to 1938, the Territory has fulfilled the provisions of the Hawaii Act of 1928, which stipulates that "the Territory shall make provision for such additional buildings and permanent equipment as may be necessary for the development of the work." During this period the experimental work at the branch stations at Haleakala near Makawao on Maui and at Kainaliu in the Kona District of Hawaii was greatly expanded and placed on a project basis with supervision and direction from the central station. In 1937, the area of the Kona station was increased by the addition of 7.5 acres of land to be used for fruit, nut, taro, pasture, and other investigations. The lands, buildings, equipments, and herds at the University have been developed, for both academic and research work. Of particular significance will be the construction, in 1939, of a new wing to the agricultural building which will materially enlarge the essential research laboratory facilities of the experiment station.

The investigations in progress at the central station and at the branches have taken on greater significance and importance, due largely to increased facilities and trained personnel. At the Kona Branch Station the coffee investigations now include detailed studies of fertilization, pruning, and processing. The nursery work pertaining to selection, propagation, and testing of macadamia varieties, together with comparative tests of "rough" and "smooth" types of rootstocks, requires a large proportion of the available area. Tests of other fruits, such as avocado, banana, litchi, and longan, also are being expanded. At the Haleakala station studies of range grasses and forages and problems of grazing and range management are given primary consideration, although experiments with truck crops and with macadamia and small fruits are in progress. Poamoho Farm is being developed as the central field-research station, where breeding, cultural, and physiological investigations with potatoes, macadamias, papayas, truck crops, grasses, and other important crops are being conducted. The land and buildings of the former Federal station at Pensacola and Prospect Streets will be used by the experiment station in coming years until some disposition of them is made by the Federal Government. Thus the facilities of the station for conducting research at strategic points throughout the Territory have materially increased.

Of particular value and significance has been the cooperation between the experiment station and various individuals or corporations in attacking certain problems, the solution of which may be of considerable importance in stimulating greater agricultural diversification in the Territory. Arrangements for collaboration have existed with several of the sugar plantations, pineapple companies, ranchers, and with a number of individuals. Investigations relating to coffee fertilization and pruning; macadamia variety selection and testing; papaya breeding; cattle feeding and range management; cattle, hog, and poultry feeds (particularly local by-products); and liver-fluke control are among the cooperative projects. Close relations have also existed with sugar and pineapple research stations of the Territory and with several departments of the Territorial and Federal governments, especially the Department of Public Health, the Bureau of Biological Survey, and the Bureau of Chemistry and Soils.

The facilities of the station have materially increased during the past 9 years, but it has been in the last 3 years, due to sugar-tax funds, increased Territorial support, the assembling of a small but efficient technical staff, excellent cooperative arrangements, etc., that the activities and progress of the experimental work have commanded general interest in the Territory.

MAJOR RESEARCH ACCOMPLISHMENTS

Some of the major accomplishments of the research staff during the past year and their implications to the Territory may be briefly stated.

A genetic factorial explanation for sex inheritance in the papaya was established. In addition to its scientific value, this finding immediately clarifies the whole problem of developing uniform, disease-resistant strains of high quality. Work along such lines is proceeding rapidly.

The asexual propagation of macadamia and litchi by grafting has been made commercially practicable by discovery of the relationships of food storage in the stock and scion to the formation of graft unions. Utilization of hormones and vitamins in stimulating graft union and root production by cuttings of these plants is in progress.

The first orchard of grafted macadamia varieties in the world was planted on March 23, 1938 by the experiment station, in Kohala, Hawaii. The orchard consists of 9 trees each of 25 varieties, covering about 10 acres, and is the first comparative variety trial of selections made by the experiment station. This orchard will be expanded in future years. Smaller plantings were made at the branch stations at Makawao and Poamoho during the same year. A total of 85 varieties of macadamia have been selected and propagated for test and final selection of the 8 or 10 most promising types.

Spindling-sprout of the white or Irish potato was clearly shown to be a physiological disease rather than one of virus origin, as believed by most observers on the mainland. Healthy tubers grafted with cores of spindling-sprout tubers showed greater vigor, growth, and yield. Efforts to isolate the stimulating principle were unsuccessful. A clearer understanding of this disease gives a further assurance of successful potato culture in the Territory.

Mechanical transmission of the yellow-spot disease of pineapple from the weed host *Emilia sonchifolia* to tomato and potato has shown the relationship and importance of this disease in the field and has aided in identification. Further work will be necessary to develop control measures or to select resistant varieties.

The discovery and indentification of *Claviceps paspali* (ergot) in the sclerotial and honeydew stages on *Paspalum dilatatum* and *P. orbiculare* were announced. This organism, if unchecked, may become a serious economic problem to local ranchers.

Studies of the chemical and physical properties of Hawaiian soils have far-reaching importance in maintenance of fertility and in moisture relations. The carbon and nitrogen contents and carbon-nitrogen ratios of a wide range of soils were shown to be related to the rainfall and temperature. The importance of organic matter in the nitrogen cycle and the base exchange properties of local soils was demonstrated.

The development by breeding of improved types of sweet corn, Irish potatoes, sweetpotatoes, lettuce, tomatoes, and beans is progressing rapidly. Well-adapted, resistant varieties will do much to remove the uncertainties surrounding the production of these important crops.

A vegetative survey of Hawaiian pastures and classification of climatic zones, well along toward completion, may do much to improve pastures and pasture management.

The digestion coefficients of local feeds, the palatability of common pasture grasses, the comparative value of Sudan, Rhodes, Napier, and panicum grasses as roughages for dairy cows, and the value of cane molasses in fattening beef cattle are some of the important phases of livestock investigations. The safe and economic use of cane molasses and other byproducts of the sugar and pineapple industries may do much to make Hawaii independent of mainland sources of concentrates in cattle, swine, and poultry feeding.

The treatment of cattle for liver-fluke infection with Distol and kamala has shown considerable promise. The liver fluke is a serious parasite of cattle on wet and swampy ranges and in dairy pastures. An effective, cheap method of treatment will increase the production of both beef and milk in the Territory.

The introduction, development, and management of chick batteries and wire-floored houses have reduced the mortality of chicks at the experiment station to a marked degree. This equipment and the methods established are being widely adopted by commercial poultrymen and should greatly reduce the cost of production.

The improvement of market poultry by crossbreeding was shown to be commercially practicable in Hawaii.

Work on the nutritive value and chemical composition of Hawaiian foods was continued. Surveys of the value of the diets of local people have been inaugurated, the first having been conducted with Japanese farmers. Studies on pernicious anemia are also being carried forward actively.

PERSONNEL

At the close of the fiscal year the commissioned full-time and part-time employees of the experiment station totaled 40, as compared with 53 at the close of the previous year.

Dr. O. C. Magistad, director, left the Territory on March 12, 1938, to become director of the U. S. Regional Salinity Station for the Western

States, located at Riverside, California. Dr. Magistad became director on July 1, 1935, and the accomplishments of the past 3 years have been due in large part to his helpful guidance.

It is with deep regret that we record the deaths of J. M. Westgate, consultant in tropical agriculture and former director of the station, and of L. D. Whitney, assistant agronomist.

Separations from the scientific staff during the year included: F. A. I. Bowers, principal agricultural aide in agronomy; E. M. Bilger, collaborator in chemistry; R. R. Thompson, scientific aide in chemistry; R. H. Moltzau, principal agricultural aide in horticulture; J. C. Thompson, principal scientific aide in horticulture; H. G. Hansen, district agent, Bureau of Biological Survey; F. L. Brown, foreman, Poamoho Farm; F. A. Elliott, assistant biological aide; Ernest T. Watanabe, minor scientific helper in chemistry; Clarence Lyman, graduate research assistant in chemistry; and Harry K. Lee, under biological aide.

Additions to the scientific staff during the year included: F. G. Holdaway, entomologist; Amy Suehiro, assistant in entomology; J. H. Payne, associate chemist; Kathleen Pierson, editor; M. L. McDougal, foreman, Poamoho Farm; Teruo Togashi, assistant in agronomy; Paul Guest, research assistant in horticulture; and Lucille Louis, assistant in foods and nutrition.

HORTICULTURE

Papaya

Genetics

The sex ratios of *Carica papaya*, on the basis of certain controlled pollinations, were previously determined to be:

1. Female × male.............................1 female: 1 male
2. Female × hermaphrodite..........1 female: 1 hermaphrodite
3. Hermaphrodite selfed..................1 female: 2 hermaphrodites: 0.05 male
4. Male selfed.................................1 female: 2 males

Continued study has shown that these ratios hold true excepting that of the hermaphrodite selfed. The 0.05 ratio of males in the progeny of the latter apparently was caused by accident or by contamination during pollination. Subsequent self-pollinations of hermaphrodites show this ratio to be 1 female to 2 hermaphrodites.

A fifth ratio has been established, viz, the segregation of hermaphrodite × male, as follows—1 female: 1 hermaphrodite: 1 male.

These ratios suggest that sex in the papaya is determined by definite genetic factors and that the male and hermaphrodite are permanently heterozygous. With an arbitrary designation of A, A^1, and a for male, hermaphrodite, and female respectively, the genotypes of the sexes would be: Male, Aa; hermaphrodite, A^1a, and female, aa. If it is assumed that AA, A^1A, and A^1A^1 are lethal, the ratios may readily be explained. It is now established that the homozygous dominant genotype is lethal, the seed failing to develop a normal visible embryo. This lethal effect may be detected in all fruit borne by hermaphrodite and male trees but does not occur in fruit of female trees where only Aa, A^1a, and aa genotypes are possible.

The detection of nonviable seed may be easy or difficult depending upon the variety or strain. In some strains, such as Solo, the seed coats develop and darken at maturity, but the resulting seed are usually slightly smaller than the normal viable seed. With seed cut in half, the lethal effect is evident in the dark, watery endosperms or the complete lack of embryos, in contrast to the full white embryos of normal seed. In other strains, such as Cuba[1], Fiji, Watermelon, Haiti, etc., the nonviable seed do not always develop fully nor do the seed coats darken, and the separation of the white nonviable seed from the dark viable seed is a relatively simple matter.

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[1] The names used are those arbitrarily given at the experiment station and correspond, usually, to the country from which the seed was received.

It has been noted that in unfertilized ovules no development of the funiculus occurs; in fertilized ovules, even though the nonviable seed is so small as almost to escape detection, the funiculus upon which it rests is well developed.

The results of examining fruits for the lethal effect upon the seeds are given in table 1.

TABLE 1.—Results of seed examination for lethal effect in male, hermaphrodite, and female papaya fruits of nine varieties (condensed)

Type	Number of fruit examined	Total seed examined	Number of nonviable seed	Percentage of nonviable seed
Male	4	1,850	459	24.81
Hermaphrodite	17	10,651	2,656	24.94
Female	6	3,991	50	1.25

The results shown in table 1 come very close to theoretical expectations of viable seed in ratios of 25:25:0 for male, hermaphrodite, and female fruits respectively.

The establishment of a factorial basis for sex inheritance in *Carica papaya*, assuming a lethal effect of the homozygous dominant genotype, and the actual demonstration by ratios of this effect upon the seed, appear to be ample evidence of true Mendelian inheritance involving allelomorphic factors. (Storey)

Breeding and Selection

Crosses have been made between Solo papaya and other strains having such plant characters as mildew resistance, semi-dwarfness, low-branching habit, or desirable size, thickness, or color of flesh, and the progenies have been set for fruiting at Poamoho Farm. By selection and inbreeding, it should be possible to combine the desirable qualities of both parents in new strains or varieties.

Progenies of crosses made at Kailua in 1936, chiefly between different types within the Solo strain, were set out and are now fruiting at Waialua. Data on the inheritance of size and shape of fruit, thickness of flesh, depth of sutures, and other characters are being obtained. (Storey)

Sterilization and Storage

The purpose of these investigations was twofold: (1) To determine the proper stage of maturity of fruit for sterilization treatment to kill fruitfly, and (2) to determine the best storage conditions for extending the life of the fruit and maintaining high quality after such treatment. Cold treatment for 12 days at 32° to 34° F. killed all fruitfly eggs and larvae without appreciable injury to ripe fruit, if certain precautions were taken. The treatment seriously affected mature-green and firm-ripe fruit. A more promising commercial method of sterilization was fumigation with methyl bromide. After the air had been exhausted under a 27-inch vacuum, the fruit was treated with a mixture of methyl bromide and air for a period of 1½ hours or longer at room temperature. After treatment, the gas and air mixture was exhausted under vacuum.

To study the effects of methyl bromide on quality, respiration, and chemical composition of the papaya, several lots of fruit have been treated, as described above, through the cooperation of Mr. L. A. Whitney of the Territorial Plant Quarantine. Ripe fruit did not withstand the vacuum treatment, due to crushing of the fruit when the vacuum was released. It was found necessary to use firm-ripe or mature-green fruit. Papayas harvested firm-ripe and held at room temperature ripened in 3 or 4 days, so that it was necessary to combine cold storage with the methyl-bromide treatment in order to lengthen the life of the fruit. Certain lots of fruit were ripened at room temperature after methyl-bromide treatment and then placed in cold storage, while others were held in cold storage (where very little ripening occurs) for varying periods and then ripened at room temperature. Untreated fruit, given the same storage treatments, served as controls.

The effects of cold storage on the quality and appearance of four lots of papayas, examined 17 days after harvest, are shown in table 2.

It appeared, from these data, that firm ripe fruit, sterilized and stored at 40° F., did not develop as high quality as fruit allowed to ripen for

TABLE 2.—Quality and appearance of papaya fruit 17 days after harvest, after storage under various conditions

Conditions of ripening	Quality	Appearance
Ripened 3 days before cold storage[1]	Excellent	Good
Do[2]	do	do
Ripened 4 days after cold storage[1]	Poor-watery	do
Do[2]	do	do

[1] Treated with methyl bromide.

[2] Controls.

several days after treatment and then placed in storage. Wastage of the former class of fruit also appeared to be greater.

Chemical analyses of the fruit treated with methyl bromide are presented in table 3.

TABLE 3.—Composition of papaya fruit after treatment with methyl bromide, when ripened before cold storage at 40° F. and when ripened after cold storage

Contents	Fruit treated with methyl bromide and ripened before cold storage	Control fruit, ripened before cold storage	Fruit treated with methyl bromide and ripened after cold storage	Control fruit, ripened after cold storage
	Percent	*Percent*	*Percent*	*Percent*
Water	88.91	89.53	91.58	90.07
Soluble solids[1]	74.86	73.08	72.98	71.64
Reducing sugar	45.54	40.45	49.64	43.43
Sucrose	11.94	14.71	7.31	16.22
Total sugar	57.48	55.16	56.95	59.65
Soluble nitrogen	.50	.50	.43	.44
Insoluble nitrogen	.33	.34	.33	.40
Total nitrogen	.83	.84	.76	.84

[1] All results except moisture expressed as percentages of dry weight.

Of interest in table 3 are the high reducing-sugar content and the low sucrose content of the methyl-bromide-treated fruit as compared with the untreated fruit.

Several experiments have been conducted to determine the effect of methyl-bromide pretreatment on the metabolism of the fruit during storage. In figure 1 are presented results obtained from duplicate lots of firm-ripe fruit held at 40° F. for 11 days. The two upper lines of the graph represent the successive determinations of carbon dioxide evolved by two lots of treated fruit; the two lower lines are for control lots. It is apparent that the methyl-bromide treatment caused an acceleration of carbon-dioxide evolution.

The experiments on sterilization and storage of the papaya indicate that the fruit may be treated to kill Mediterranean fruitfly and held for a period of 2 weeks or longer in storage at 40° F. However, two storage diseases appear to be serious. These, according to Dr. G. K. Parris, are caused by species of *Colletotrichum* and of *Rhizopus*. A dip of 1 percent boric acid at 40° F. for 1 minute has given some control. (Jones)

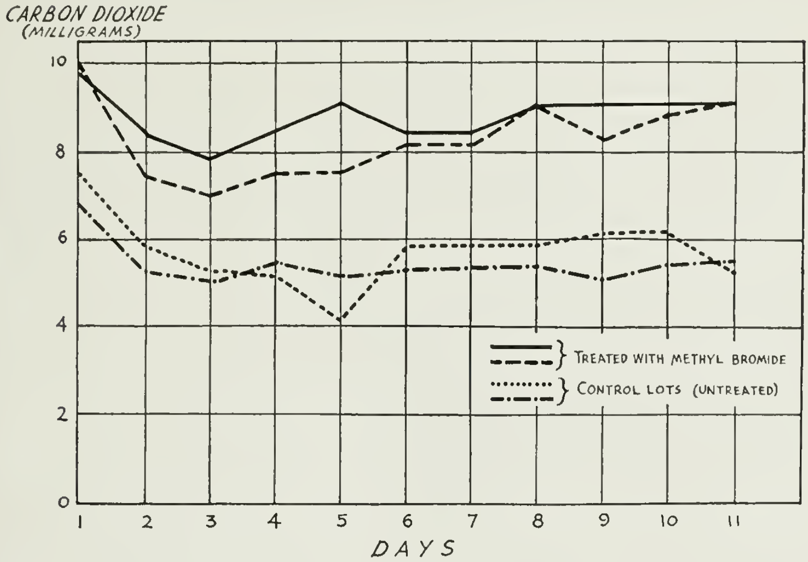

FIGURE 1. — Effects of methyl-bromide treatment on the respiration of papaya fruit stored at 40° ± 1° F. (expressed as milligrams of carbon dioxide evolved per kilogram of fruit per hour).

MACADAMIA

Morphology

The testa, or shell, of the macadamia is made up of two distinct layers. The outer, thicker portion is a very hard, sclerenchymatous tissue of fiber and stone cells. The inner layer is only about one-fifteenth as thick as the outer layer; one half, toward the micropylar end, is cream-colored and enamel-like, while the other half, which develops around the embryo at its apical or broader end, is shiny and dark brown.

In previous reports the inner layer has been described as having developed from the inner integument. Further study of the structure of the macadamia fruit has shown that the shell enclosing the kernel is made up entirely of outer integument, the cells of the cream-colored portion deriving from the inner epidermis of the outer integument. The inner integument remains intact through the early stages of development, but in later stages is present as a layer of disintegrated tissue adhering to the cream-colored portion of the inner surface of the shell, or testa. (Storey, Hartung)

Breeding and Selection

During the past 2 years, practically all of the bearing macadamia trees in the Territory, with the exception of one large orchard, have been surveyed for the purpose of selecting and propagating outstanding seedling trees. In the year 1937-38, 42 selections were made, making a total of 82 for the 2-year period. With the exception of 10, all selections are of the smooth-shell variety (*Macadamia ternifolia* var. *integrifolia*). As in the previous year, emphasis was placed on the characteristics of the nut although consideration was also given to apparently desirable tree characteristics.

To gain information as to the effect of season on the principal nut dimensions, samples of nuts harvested from selected trees at three locations in the past 2 years have been compared statistically. The results may be briefly summarized as follows:

1. Nuts from Hoaeae and Nutridge were significantly heavier in weight in 1937 than in 1936 while those from Keauhou were not. The maximum average difference was 1.3 grams per nut, or approximately 22 percent, at Nutridge.
2. The diameter of nut and the thickness of shell at the side showed slight positive differences in 1937 at all locations, but these were not statistically significant.
3. The thickness of shell at the base was over 10 percent less in 1937 than in 1936 at all locations, and the differences were statistically significant.
4. Kernel weight was significantly greater in 1937 than in 1936 at Hoaeae only.

The greatest variations occurred in weight of nut, and may have been caused, at least in part, by a change in drying procedure. These studies will be continued and eventually will include the asexual progeny grown at several locations.

A system of rating samples of nuts from selected trees is of importance from several standpoints: (1) As an aid in making selections; (2) as a means of comparing the asexual progeny with the parent trees; and (3) as a means of comparing cultural or environmental effects. A number of the regression coefficients calculated from the principal measurements made of samples of nuts from 313 trees proved to be statistically significant. The statistical analysis of these trees was extended and six of the significant regressions were graphed. The 82 trees selected for propagation have been spotted on these graphs as illustrated in figure 2.

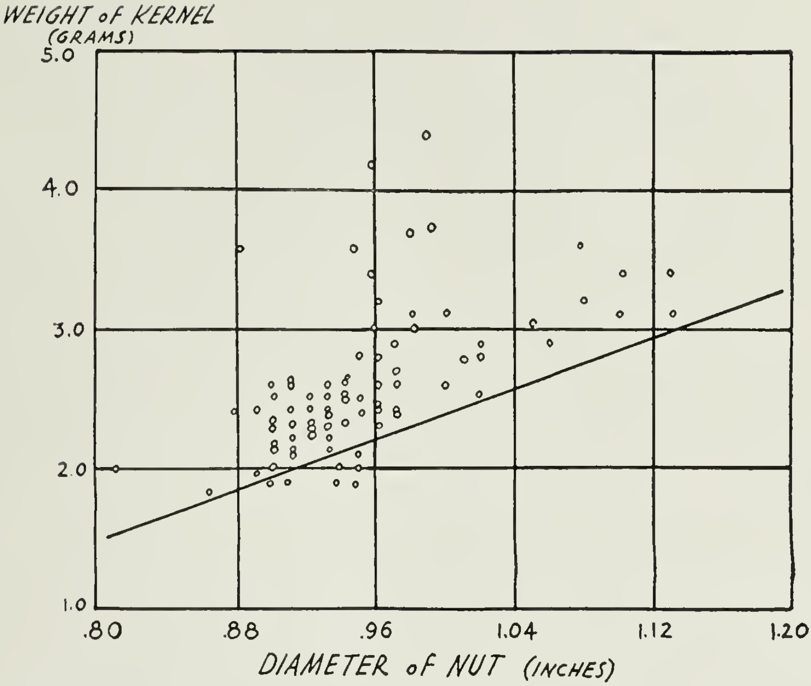

FIGURE 2.—Macadamia nut selections: Regression of weight of kernel on diameter, 1936-37 ($n^1 = 313$; $b = 4.495$; $t = 10.455$)

The varieties poorer than average as represented by the regression lines were given minus ratings. Thus, from the six regression lines it was possible for a variety to receive a —6 rating. In addition, two arbitrary standards were set up, viz, trees with nuts averaging less than 0.9 inch in diameter or less than 2.5 grams in kernel weight were also given minus ratings making a possible total of —8. Further modifications of the system of rating are possible as, for example, the deviation above or below the line to give a further segregation of varieties.

The 82 numbered varieties selected during the past 2 years have been segregated according to their ratings, as summarized below: (Beaumont)

Rating	Number of trees
0	17
—1	15
—2	31
—3	11
—4	4
—5	2
—6	2
—7	0
—8	0

Variety Testing

Of 40 seedling-tree selections propagated and grown in the nursery at Kona during 1936-37, sufficient plants were available to set out 3 comparative tests during the winter of 1937-38. These tests were planted at Kohala, Hawaii; Makawao, Maui; and Kona, Hawaii. Two additional tests are being held in the nursery at Kona until suitable arrangements for their planting are made. Each of the first three tests is divided into three groups of horticultural varieties, and in each group the varieties are replicated two or three times. In addition, each group contains three check varieties common to all groups. The 1937-38 selections will also be set out in similar manner, with each new planting containing the same three checks. By this arrangement, it will be possible to compare the groups through the check varieties, while differences in age, time of planting, and other variables will be compensated in part. This plan should prove of special value as additions are made over a period of several years. Forty-two additional selections will be tested in 1938-39. (Beaumont)

Cultural Investigations

An experiment set out at Poamoho Farm was designed to show the relative values of three cultural practices (clean culture, permanent sod plus sod mulch, and clean culture plus cover crops), and of three treatments with nitrogen (fall, spring, and fall plus spring), as well as the interaction between culture and application of nitrogen on the growth and fruiting of the macadamia. Three horticultural varieties were used, so that variety will also be a variable. The trees were planted closely but in such a manner that alternate trees may later be removed, leaving the experiment unchanged except for reduction of number of trees by one-half. Cultural and nitrogen treatments will not be initiated until the trees become established and are growing well.

Individual-tree yield records on 12 trees at Nutridge were furnished the department. These trees were paired according to their average yields and a series of three nitrogen treatments was initiated, primarily to observe whether high nitrogen applications at flowering would influence fruit set.

A comparison of *Macadamia ternifolia* as a rootstock with *M. ternifolia* var. *integrifolia* was initiated at Poamoho, using the guard rows and a triangular corner of the experimental field. Selected horticultural varieties of the smooth-shell type grafted on both rough-shell and smooth-shell rootstocks were planted at random in the guard rows. Within each variety, however, the rough-shell and smooth-shell rootstocks were systematically paired. Sufficient trees were available to make two replications of the test, using two trees of a variety in each replication.

Topworking the macadamia has proven feasible though uncertain except with young trees. The most serious difficulties encountered in topworking were wood-rotting fungi and sunscald. The wood rots became established in both the cut stubs of branches and in sunscald wounds. Cut branches did not heal rapidly, especially when shoots or suckers were grafted. (Beaumont)

Growth Habits

To determine the interrelationships of growth, flowering, fruit setting, and fruit development of the macadamia, detailed growth and chemical measurements are being accumulated. Growth is irregular, continuing for a short period and stopping, to be followed after a time by another flush of growth—often with three or four such growth cycles during a year. In order for a flush of growth to occur, there must be an accumulation of reserve materials in the plant in sufficient quantity to furnish energy and building material. Studies covering one reproductive period will soon be complete, and will show the chemical composition of the vegetative branches before and after a flush of growth and during flowering and maturing of the crop. (Jones, Cooil)

Oil Storage

A study has been completed on the accumulation of oil in the embryo of the macadamia. The results of this study may be summarized as follows:

(1) There is very little oil formation in the macadamia embryo during the first 3 months after flowering.

(2) A rapid increase in oil begins around the time the shell hardens.

(3) Nitrogen in the embryo decreases with oil formation when calculated as percentage of total dry weight, but increases when calculated as percentage of the ether-extract residue.

(4) Percentage of reducing sugar decreases with oil formation to maturity, while percentage of sucrose increases until about 185 days after flowering and then decreases to maturity. (Jones)

Chlorosis

Chlorosis of macadamia occurs in several districts in the Territory, becoming so severe as to cause considerable dieback and, in some instances, death of the trees. A study of the conditions under which the chlorosis occurs indicated that the causal factors may be associated with differences in soil composition and pH, and in rainfall and light. There were indications also of genetic differences between seedling trees with respect to susceptibility to chlorosis.

Soils from various chlorotic and nonchlorotic areas are being analyzed to determine whether deficiencies or excesses of mineral elements may be associated with chlorosis. Seedling trees are also being grown in the soils to obtain biological readings.

A foliar diagnosis is being made of chlorotic and nonchlorotic leaves from bearing trees in order to determine basic differences in their chemical composition, and an analysis of stems and roots of chlorotic and nonchlorotic seedlings.

Seeds from 32 selected trees were planted in a chlorotic area to determine whether the progeny from individual trees exhibit significant differences in their susceptibility to chlorosis.

Control measures, such as the application of soil correctives, foliar sprays, or other methods of treatment, will be undertaken as soon as the results of soil and plant analyses are available. (Guest)

COFFEE

Cultural Investigations

A statistical analysis of growth and yield relationships of coffee trees in the Kona District was completed during the year. Two groups of trees were studied—the Fukuda trees, which were 12 years of age, heavily fertilized, and in a high state of vigor and production; and the Akamatsu trees, which were 7 years of age, had received no fertilizers in 2 years, and were relatively poor in vigor and production. Both groups had been trained to a multiple-vertical system, but the Fukuda trees had received only unsystematic renewal pruning. In most other respects, such as soil type, elevation, and weeding, the experimental plats were uniform, and the differences between the trees could be ascribed mostly to age and fertilization.

Individual tree yields for 2 years were available for the Fukuda trees, and for 1 year for the Akamatsu trees. Terminal growth, lateral growth, and trunk circumference measurements were obtained on both groups of trees, and partial and simple regressions calculated. Sampling errors were determined in order to judge the significance of the various regression coefficients.

Where comparable measurements were made on both groups of trees, the same interrelationships of yield on growth were found, in spite of differences in age, condition, and yield, with one exception, that the 1937 yield on 1936 terminal growth of the Akamatsu trees was found to be significant while with the Fukuda trees it was not. The renewal pruning practiced on the Fukuda trees may have destroyed this relationship. From the analysis, it was concluded that:

(1) Certain growth responses of the tree are largely dependent upon, or conditioned by, the size or volume of the developing crop.

(2) The volume of the crop is largely determined by growth made in the preceding growing and crop season.

(3) A dominant weather factor, such as spring rains, may disturb these relationships or equilibria, but the tree will resume its normal, overlapping, 2-year growth and bearing cycle in succeeding average years.

(4) It should be possible, by judicious fertilization and pruning, to reduce the extreme biennial variations in growth and yield typical of the district, and exhibited in marked degree by the Fukuda trees. (Beaumont)

Methods of Pruning

During the past 2 years, 8 pruning and training types applicable to coffee trees were established for study and observation, with 40 trees at the Kona Branch Station and 48 trees on the Yonemura farm. Systems of renewal pruning of multiple-vertical-type trees and rates of pruning of topped trees are being given first consideration. The trees are producing their first crop on renewal wood in the present season.

From observations of the pruning systems it is apparent that there are several advantages to the bending of old verticals to an angle of 45 degrees at the time the verticals would normally be removed. The lateral branches of bent-over verticals grow and yield reasonably well. Secondary verticals that develop along the bent-over verticals grow to considerable size and will fruit in the second year. No more than three secondary verticals should be permitted to develop on a single bent-over vertical and the first secondary vertical should not be closer than about 3 feet to the axis of the tree. When all secondary verticals are removed, a greater growth response is obtained from the laterals of the bent-over vertical. Whether the yield of these laterals will be greater or less than is obtained from secondary verticals will be observed in 1938. The development of new primary verticals in full sunlight results in stocky, thrifty growth with short internodes and long laterals. The entire bearing surface is thus brought close to the ground. These new primaries do not fruit heavily in the second year but the indicated high yield, quality, and ease of picking of the crop in the third year will afford a basis for determining the relative advantages of the different pruning systems. (Beaumont)

MANGO

Composition of the Fruit

The composition of mango fruit at various stages of maturity has been studied as a preliminary to storage trials. Table 4 gives the results.

It will be noted that there is a very marked increase in sucrose with a corresponding decrease in acid-hydrolyzable material during ripening. (Kubota, Jones)

Storage

It has been found that fruit harvested ripe, or harvested mature but not ripe (mature-green) and allowed to ripen at room temperature, subsequently held its high quality in storage at 3° to 4° C. for a period of 2 weeks or longer. With green fruit there was little ripening during cold storage, and upon removal to room temperature the fruit decayed without ripening. (Kubota, Jones)

SMALL FRUITS

One hundred plants each of youngberry and boysenberry were set out at Makawao, Maui, to determine growth and fruiting behavior. The plants were spaced so that pruning and training systems might also be studied. Similar plantings will be made on Kauai and in Kona, Hawaii, if it becomes apparent that these brambles can be grown successfully. (Beaumont)

CITRUS

Arrangements have been made with cooperators to interplant citrus varieties in macadamia variety plantings, and also to establish a planting at Kona. The plants have been propagated and will be set out in 1938-39. Twenty-eight citrus accessions, received from Florida, were propagated and set out in orchard form for fruiting at the Pensacola Street Station. (Beaumont)

POTATOES

Breeding and Selection

Breeding investigations of potatoes have included the testing of several improved varieties and a large number of selections from hybrids

TABLE 4. — Chemical composition of mango fruit[1]

Condition of fruit	Reducing sugar	Sucrose	Total sugar	Soluble nitrogen	Insoluble nitrogen	Total nitrogen	Acid-hydrolyzable material	Moisture
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Harvested ripe	15.93	57.23	73.16	0.51	0.29	0.80	6.38	82.87
Harvested green	9.99	15.23	25.22	.35	.27	.62	45.89	81.39
Harvested green—ripened in 4 days at room temperature	15.83	54.14	69.97	.34	.27	.61	8.87	82.77
Harvested ripe—overripe in 4 days	15.53	63.38	78.91	.41	.28	.69	2.12	83.11
Harvested green—green after 4 days	20.36	26.07	46.43	.29	.24	.53	32.89	83.65

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[1] All calculations, except percentage of moisture, are on a dry-weight basis.

developed principally by the U. S. Department of Agriculture. The purpose of the trials is to isolate strains better adapted to Hawaiian conditions than those now available. During the year, 503 accessions have been grown, of which the great majority were unnamed. They exhibited such characters as high yield, good quality, desirable size or shape, uniformity, shallow eyes, smoothness, earliness, vigor, and resistance to scab, drought, or late blight.

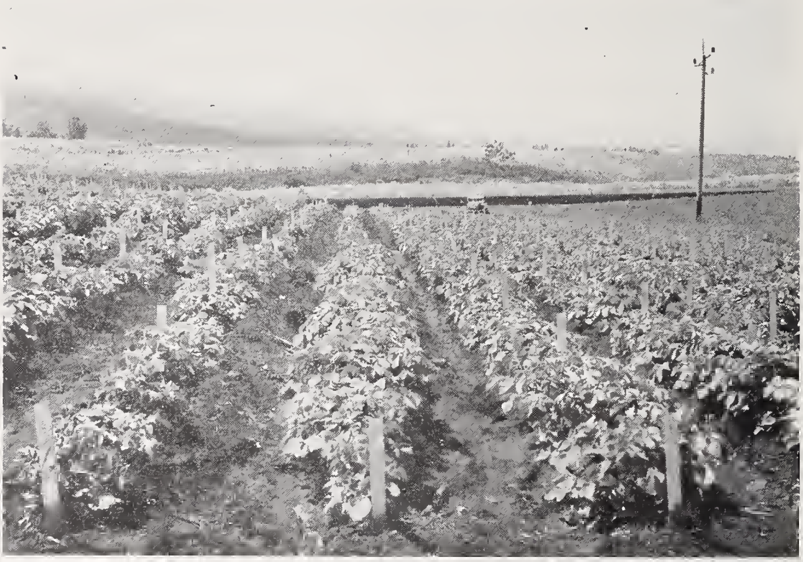

FIGURE 3. — Testing hybrid-potato selections at Poamoho Farm (planted on Feb. 15, 1938 and photographed 23 days later)

The material has been tested during the winter season at relatively low elevations (fig. 3). Under these growing conditions the most serious production trouble was infection by early or alternaria blight. Although some of the hybrid selections exhibited apparent resistance to the alternaria fungus, the high-yielding accessions were usually seriously affected by blight after 90 days in the field. Rigorous selection has eliminated many of the introductions, but the most promising unnamed strains and all the named improved varieties have been saved for seed.

Variety Testing

In January an extensive trial of commercial varieties from various seed sources was planted at Poamoho Farm. Successive harvests of sub-plats were made after 60, 70, and 80 days. The rows were spaced at 34-inch intervals and the plants were 9 inches apart in the rows. Table 5 lists the yields, in pounds per acre, of No. 1 plus No. 2 tubers of each variety at the final harvest, after 80 days in the field.

TABLE 5. — Potato variety and strain yields

Yield order	Variety	Source	Type of seed planted	Yield per acre of No. 1 plus No. 2 tubers[1]
				Pounds
1	Bliss Triumph	Dillon, Montana	Cut	18,306
2	do	do	Drop	17,740
3	do	Zurich, Montana	do	17,264
4	Katahdin	Dillon, Montana	Cut	15,001
5	Chippewa	do	do	14,948
6	Bliss Triumph	Zurich, Montana	do	14,066
7	British Queen	Dillon, Montana	do	13,656
8	Red McClure	do	Drop	12,992
9	White Rose	do	Cut	12,845
10	Red McClure	do	do	11,012
11	Netted Gem	do	Drop	6,843

[1] Yield differences of 2,361 pounds are considered significant.

There were, in general, no significant differences between cut and drop seed of the same strain. At the three harvest periods, the high-yielding varieties maintained a reasonably consistent order, with increasing successive weights. (Welch, Sumida)

Cultural Investigations

Row-spacing tests with potatoes were conducted at Poamoho Farm during the past season to determine cultural methods by which yields can be increased. These tests comprised three treatments; namely, twin rows, single rows, and alternating twin and single rows. One experiment was planted with 34 inches and another with 40 inches between rows. The Dillon strain of Bliss Triumph, which was included in the variety test, was the accession planted. Following is a summary of results:

(1) Single-row plats yielded significantly more No. 1 tubers and No. 1 plus No. 2 tubers than either the twin-row or twin-and-single-row-alternating plats in both the 34- and 40-inch row spacings.

(2) The twin-row and alternating-twin-and-single-row plantings yielded only about one-half and one-third as much, respectively, as the single-row planting, in proportion to the seed planted.

(3) Early blight was a serious factor in reducing all yields. (Welch, Sumida)

Storage

Seed potatoes, harvested on June 2, 1937, were held in storage at several controlled temperatures and planted in the field in six replicated plots on October 5, 1937. The results of the harvest, on January 12, 1938, are shown in table 6.

TABLE 6. — Yields of potatoes from seed stored at various controlled temperatures

Storage conditions	Germination	Yield per acre[1]
	Percent	*Pounds*
Room temperature	60	7,379
50° F. transferred to room temperature 3 weeks before planting	91	14,071
40° F. transferred to room temperature 3 weeks before planting	82	10,612
32° to 34° F. transferred to room temperature 3 weeks before planting	13	1,420[2]
40° F. transferred to room temperature 3 weeks before planting (cut seed)	66	8,876
50° F. to time of planting	88	14,905
40° F. to time of planting	80	13,011
32° to 34° F. to time of planting	2	195

[1] 1,021 lbs. difference required for significance.

[2] This treatment yielded only enough sound seed for one plat; consequently it was not included in the calculations.

It will be noted that potatoes stored at 50° F. gave the largest yields but there was no advantage in holding the seed at room temperature for 3 weeks before planting. This experiment is being repeated with two additional temperatures and with larger quantities of seed. (Welch, Jones)

Spindling-Sprout

Spindling-sprout of potatoes is an abnormal condition characterized by the premature production of slender sprouts and a sharp decrease in yield when affected tubers are planted. During the past season, several shipments of seed potatoes from mainland United States, particularly North Dakota, showed appreciable amounts of spindling-sprout tubers. Investigations were undertaken to determine the nature and cause of the condition.

It was found that spindling-sprout, in the true sense of the word, was not transmitted to normal tubers by core-grafting. However, bud stimulation took place in the normal portion of the tuber when the graft was made, and yields were statistically higher than yields of normal tubers grafted with normal cores or left ungrafted. A bud from a normal tuber, core-grafted into a spindling-sprout tuber, was normal as to leaf and stem development. These results seem to indicate that spindling-sprout is not of virus origin. Spindling-sprout tubers contained more soluble materials (sugars, ammonia, and amino nitrogen) than normal tubers, but they were lower than normal in insoluble proteins. (Jones, Parris, Beaumont)

TRUCK CROPS

Tests of important varieties of several vegetables have been conducted at Waipahu, Oahu; Waialua, Oahu (Poamoho Farm); Kamuela, Hawaii (Waimea district); and Makawao, Maui (Haleakala Branch Station).

The experiment grounds at Waipahu are located at an elevation of 400 feet. The section receives approximately 30 inches of rain per year, confined mostly to the late fall, winter, and early spring months; and irrigation is practiced.

Poamoho Farm is situated 600 feet above sea level and receives about 45 inches of rain per annum, mostly in the winter. There are probably more overcast days per year at Poamoho Farm than at Waipahu. Irrigation facilities are available.

The elevation at Kamuela is 2,700 feet, and the rainfall is approximately 60 inches per year. Although the rains are heavier during the late fall, winter, and early spring months, the differences between seasons are usually not so great as at Waipahu or at Poamoho Farm. Clear days at Kamuela are rare, and drizzling rains and overcast skies are typical. Irrigation is seldom necessary.

The Haleakala Branch Station is located at an altitude of 2,150 feet. Rainfall averages 80 inches per year and is usually heaviest during the winter months. During the cool season days are ordinarily overcast, whereas summer days are more often clear than cloudy. Experiments can be irrigated at this location.

Tomatoes

During the past 2 years over 70 strains and commercial varieties of tomatoes have been tested at Waipahu. Most of the strains are unnamed hybrid selections developed by investigators working in Louisiana and Florida, where climatic conditions somewhat resemble those of the Territory. From performance records it appears that some of the Florida introductions are far superior in yield and at least equal in quality to the best commercial varieties grown in Hawaii today. The most promising accessions, together with the popular varieties grown in the Territory, are being tested at the more important tomato-producing areas throughout the Islands. (Welch, Sumida)

Beans

During the fall of 1937 bean rust became serious on the locally popular snap bean, variety Lualualei. Seed of 40 strains of rust-resistant pole-green-pod beans were secured from mainland breeders and commercial seedmen. These were planted in the greenhouse for rust inoculation studies (see p. 34), as well as in the field. Four commercial varieties were found to be resistant and, although they are not Lualualei types, can be recommended to growers for planting during rust epidemics.

Some of the unnamed rust-resistant beans possess characteristics approaching those of Lualualei. Seed of this material will be increased during the summer of 1938 and may be available for trial during the winter of 1938-39. If none meets local favor, attempts will be made to combine the rust resistance of one or more of these strains with the desirable qualities of the Lualualei by breeding. (Welch, Sumida)

Lettuce

Breeding investigations to develop curled or crisp-heading types of lettuce that will head well at low elevations, at least during the winter, and which will exhibit good quality, are continuing. For higher altitudes, it is the aim to develop strains of the Imperial type which will head better throughout the year and show less rotting than the commercial types now grown.

A number of lines superior to those now grown commercially at lower elevations have been developed by the station during the past few years. This material has been grown in field tests at Waipahu during the cool season together with a number of recently introduced varieties originated by the U. S. Department of Agriculture. On the basis of heading characteristics the new U. S. D. A. variety Cosberg exceeds by far the locally developed strains. Although this variety possesses some undesirable qualities, such as small-to-medium head size and light green foliage, it exhibits good flavor and crispness. The work with Cosberg will, therefore, be stressed in future trials.

Variety tests with lettuce at high altitudes have consisted almost entirely of planting commercial strains of the Imperial or California type at Kamuela. With favorable weather, which occurs only at infrequent intervals, good crops can be grown. The chief troubles caused by unfavorable weather are head rotting and puffy or soft heads. Of the lettuce strains grown, Imperial No. 152 is far superior to any of the others, with Imperial D ranking second. The latter does not seem to be as susceptible to rotting as Imperial No. 152 but it does not head as well. It is believed that strains of the Imperial type better adapted to this location can be developed by breeding methods. (Welch)

Sprouting Broccoli

Varietal investigations with this vegetable have been conducted at Waipahu, Kamuela, and Makawao, with the bulk of the trials at Kamuela. At the latter location sprouting broccoli can be grown with comparative ease throughout the year, provided the proper cultural methods are practiced. The variety Italian Green Sprouting has proven quite satisfactory. This vegetable is difficult to ship from the off-islands to Honolulu and should be disposed of locally unless precooling or refrigeration is provided. (Welch)

Cabbage

Cabbage variety trials have been conducted at Waipahu, Kamuela, and Makawao. Plantings have proved successful throughout the year at all of these locations. Since the Hawaii market prefers a globular, firm head weighing between 2 and 3 pounds, the investigations have emphasized varieties belonging to the Copenhagen group. Copenhagen Market, Golden Acre, and Resistant Detroit are important because of their type and earliness of maturity. (Welch, Sumida)

Celery

Golden Detroit, which is a selection from Dwarf Golden Self Blanching, and Crispheart, a green type, have been grown at Kamuela during the past year. Blight is perhaps the most serious obstacle encountered in celery production at this location. The disease appears to be controlled quite satisfactorily on the self-blanching variety Golden Detroit by Bordeaux applied at weekly intervals with a good sprayer. Crispheart is much more susceptible to the fungus and may turn black in a single night. Celery can be grown successfully throughout the year at Kamuela if particular attention is directed toward spraying and liberal fertilization. Occasionally irrigation is necessary. (Welch)

Onions

The production of bulb onions in Hawaii is extremely uncertain, and investigations have been undertaken to determine the environmental and climatic factors essential for bulb formation and for seeding. A variety test planted at Waipahu in June 1937 produced practically no marketable produce because, instead of one large bulb per plant, many small bulbs of the spring onion type were formed by vegetative division. This condition was also found in a test planted in December 1936, although division was not nearly so serious. The abundance of divided bulbs is due, in part at least, to the short days in Hawaii. The December-planted test was forming bulbs as the length of day increased, while the June planting was growing as the days became shorter. As a result of high temperatures, the onion alters its manner of reproduction from seed production to vegetative multiplication. Mother bulbs of the variety Yellow Bermuda, planted in August 1937 at Waipahu to test the possibility of producing onion seed in Hawaii, also continued to divide vegetatively. In February only a few seedstalks appeared.

WEATHER RECORDS

Physiological and cultural investigations are not complete without a knowledge of weather conditions. To fulfill this requirement, records were made of sunlight, temperature, and rainfall at five field localities; namely, Pensacola, Nutridge, Kailua, and Poamoho on the island of Oahu, and Keauhou, Kona, on the island of Hawaii.

In Hawaii, temperature conditions are generally favorable for growth throughout the year but sunlight becomes a factor of great importance in many localities. To obtain a comparative estimate of sunlight in different locations, a combination soil and air thermograph was converted into a sunlight recorder by painting the soil element black, exposing it to the sun, and calibrating the recorded chart with a foot-candle meter. The resulting differences in temperature of the soil and air elements, due to the influence of solar radiation, may thus be interpreted in terms of foot candles of light intensity.

The average weekly sunlight intensity, the average weekly day and night temperatures, and the weekly rainfall for the first 6 months of 1938 of four stations—Pensacola, Nutridge, Kailua, and Kona—are presented in figure 4.

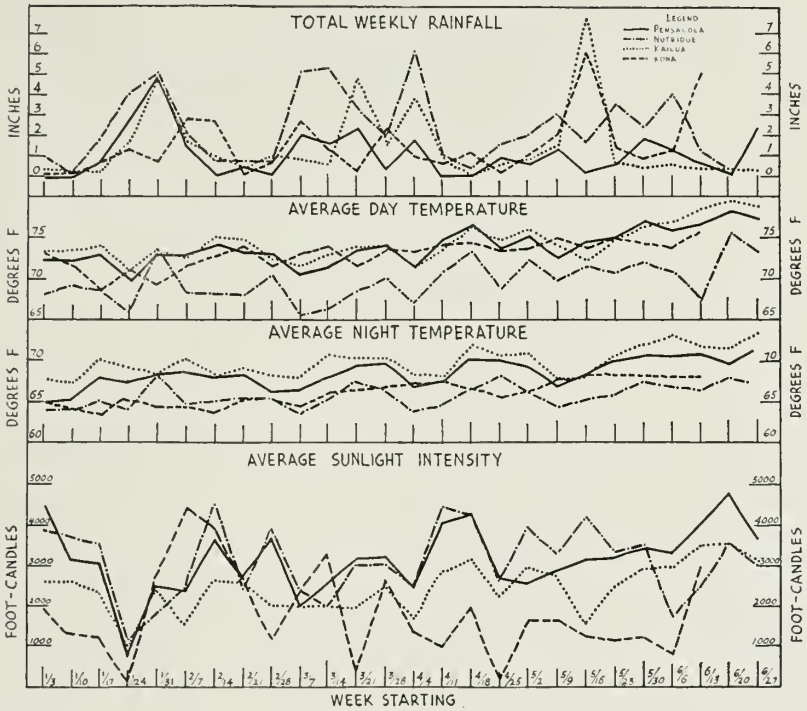

FIGURE 4.—Average weekly sunlight intensity, day and night temperatures, and rainfall at four stations (first 6 months of 1938)

The records indicate the uncertainty of the weather, by the fluctuations in sunlight, temperature, and rainfall throughout the period. There is no well-defined rainy or dry spell. The only appreciable trend is a gradual rise in the average day and night temperatures as summer approaches. (Kubota)

PLANT INTRODUCTIONS

Table 7 is a list of the seed and plant introductions made during the year. The papaya seed accessions have proven of great interest and value, having provided excellent breeding material in many instances. The successful introduction of additional litchi varieties was also gratifying. Introductions made in previous years have been planted in the variety orchards and in some cases have been distributed to cooperators who have better facilities than are available at the station for growing certain types of plants. Accessions of other economic fruits such as citrus, mango, and avocado have been propagated by grafting during the year and are ready for transplanting to field trials.

TABLE 7.—Seed and plant introductions made during the year ending June 30, 1938

Scientific name	Number of varieties	Source	Type of material
Anacardium occidentale	4	P. I. 124,952; 124,953; 124,954; 124,955	Seed
Cajanus cajan		D. T. Fleming	do
Carica papaya	1	Bombay, India	do
Do	1	P. I. 124,541	do
Do	2	Philippine Islands	do
Do	1	P. I. 124,966	do
Do	3	Habana, Cuba	do
Do	5	do	do
Do	1	F. G. Krauss	do
Do	1	La Serena, Chile	do
Do	1	P. I. 125,126	do
Do	1	San Francisco, California	do
Do	7	Jamaica	do
Garcinia mangostana		Tela, Honduras	do
Do		Canal Zone	Seed and plants
Do		D. T. Fleming	Seed
Hibiscus sp.	1	P. I. 124,636	Cuttings
Litchi chinensis	6	D. T. Fleming (from Hongkong)	Scions
Do	11	do	Scions and rooted plants
Do	8	G. W. Groff, Canton, China	Scions

TABLE 7. — Seed and plant introductions (continued)

Scientific name	Number of varieties	Source	Type of material
Macadamia ternifolia	2	Queensland, Australia	Seed
Mangifera indica	3	Java, D. E. I.	Budeyes
Do		D. T. Fleming	Seed
Do	1	Imported by Board of Agriculture and Forestry through Mr. Pemberton and turned over to Department of Horticulture by Dr. Lyon	Plants
Do		B. P. I., Manila, P. I.	Scions
Myrciaria cauliflora (Jaboticaba)	1	Canal Zone	Seed
Nephelium lappaceum (Rambutam)		Board of Agriculture and Forestry	Plants
Do		Tela, Honduras	Seed
Nephelium mutabile (Bulala)		do	Plants
Passiflora sp.	1	P. I. 124,140	Seed
Ricinus communis		D. T. Fleming	do
Rubus sp.	2	Java	do
Sensepalum dulcificum		D. T. Fleming	do
Telfairea pedata		Dr. Walter Carter	do
Lilac tree		D. T. Fleming	do
Oil tree (Yao)		do	do
Thanh Tra (Jungle fruit)		do	do

PLANT PATHOLOGY

FRUIT AND VEGETABLE DISEASES

A New Disease of Papaya

A disease of *Carica papaya,* new to Hawaii, appeared in July 1937 on the island of Oahu, where it apparently is localized. In symptoms the disease resembles "yellow crinkle," reported from Queensland by Simmonds[1]. The disease has caused appreciable losses (from 6 to over 30 percent) in several large plantings.

Stems and petioles of affected plants show linear, dark green, hydrotic streaks, 0.125 to 0.5 inch wide and 0.5 to 1 inch long. No organism has been found in these diseased tissues, and isolations have been consistently negative. Studies on the possible virus nature of this disease are being undertaken. (Parris)

Bean Rust

Bean rust, *Uromyces phaseoli typica,* in a virulent form, appeared on Oahu in December 1937 (see p. 28). Spraying with "flotation" sulphur was of some value when properly applied at regular intervals, but Bordeaux gave no control. Mainland varieties were tested as to their resistance or susceptibility by greenhouse inoculation with a suspension of uredospores in water.

Spores gathered from three sources on Oahu, two sources on Kauai, and one on Maui showed that the same physiological form of *U. phaseoli typica* was present throughout the Territory. Differences in the susceptibility of certain varieties of bean, as compared with the findings of other investigators, lead to the belief that the physiological form of rust present in Hawaii is distinct from Harter's form No. 1 or form No. 2. (Parris)

Root-knot Nematode on Tomatoes

Tests of the relative efficiency of emulsified and nonemulsified chloropicrin and carbon-bisulphide in the control of *Heterodera marioni* (Cornu) Goodey were continued, using measurements of plant stature and growth as a criterion of nematode abatement. Results showed that chloropicrin at 100 pounds per acre, emulsified and nonemulsified, are equally valuable in reducing nematode populations in the soil. Carbon-bisulphide at 200 to 225 pounds per acre is of no value in nematode abatement. (Parris, Kikuta)

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[1] SIMMONDS, J. H. DISEASES OF THE PAPAW. Queensland Agr. Jour. 48:544-552. 1937.

"Ring-Spot" of Tomatoes

The "ring-spot" disease of tomatoes noted in last year's report has been transmitted mechanically, using carborundum as abrasive, to tomato, potato, and *Emilia sonchifolia* (*flammea*) from tomato and *E. sonchifolia*, and by grafting from tomato to tomato and potato. The incubation period in the tomato is from 10 to 16 days, depending on the vigor of growth of the suscept: the more vigorous the growth after inoculation, the more rapid is the appearance of the symptoms. The virus in extracted juice rapidly lost its infectivity, and it was difficult to recover the virus from diseased plants after 1 week. The virus is not seed-transmitted, as evidenced by growing 500 seedlings from diseased plants. Symptoms exhibited by *Emilia* are identical with those reported for the virus of the yellow spot of pineapple. (Parris)

Early Blight of Potatoes (*Alternaria solani*)

The fungicidal efficiency of 4-4-50 Bordeaux mixture in the control of *A. solani* was compared with 4-2-50 Bordeaux, Coposil, and the modified Bordeaux spray schedules of Blodgett and Mader[1]. In the last-mentioned schedules, the copper concentration is varied, either a high copper tapering to a reduced copper in successive sprays (high to low), or vice versa (low to high). Coposil was applied at the rate of 2 pounds per 100 gallons. For each spray application approximately 100 gallons per acre were utilized.

Climatic conditions were excellent for fungus infection, and blight was first observed in check and Coposil-sprayed plots 35 days after planting. Ten days later the disease was present in all sprayed plots, but was more devastating in check and Coposil plots. Plants receiving the high-to-low copper schedule were noticeably stockier and possessed more leaves per plant than plants in other treatments. Check plants were dead 77 days after planting; and Coposil-sprayed plants were little better. Sprays of 4-4-50 and 4-2-50 Bordeaux did not give as good control of *A. solani* as the high-to-low Bordeaux. There were no significant differences in relative yields between unsprayed and sprayed plants. This anomaly is thought to be a result of unfavorable weather and growing conditions. Excessive cloudiness, unfavorable for photosynthesis, characterized the growing season from January to March, 1938. (Parris)

Seed-piece Rot

Potato seed, both cut and drop, were treated with Semesan and with yellow oxide of mercury to determine the relative value of the two mercurials in controlling seed-piece rot. Results showed that: (1) Semesan had no beneficial effect on germination or yield of cut or drop seed; (2) yellow oxide likewise had no beneficial effect in the control of seed-piece rot but did retard germination, a feature previously noted. Cut seed did not yield as well as drop seed (difference—15.4 ± 6.8 pounds per 100 plants). (Parris, Kikuta)

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[1] MADER, E. O. AND BLODGETT, F. M. EFFECTS OF MODIFICATIONS OF THE POTATO-SPRAY PROGRAM. New York (Cornell) Agr. Expt. Sta. Bul. 621, 1935.

DISEASES OF TARO

Soft Rot of Taro

Soft rot is caused by a proliferating *Pythium* (as yet unnamed as to species) which enters the corn by way of the root, particularly in the region of root-hair development. The fungus is not a virulent pathogene under aerobic conditions, as laboratory corm and root inoculations have shown, but under unfavorable conditions for the plant (for example, low oxygen content, high hydrogen-sulphide content, and probably toxic organic acids) it causes serious losses.

The *Pythium* sp. grows readily on all of the common synthetic media, producing an abundance of aerial mycelia but usually no fruiting bodies. Abortive sporangia were found on potato dextrose, corn meal, oatmeal, and Mehrlich's malt agars. Chlamydospores were occasionally seen in old cultures of the fungus on oatmeal and potato dextrose agars. Sporangial formation usually takes place in 48 to 60 hours at 28° to 30° C. if the aerial mycelia from 2- to 3-day-old cultures on oatmeal agar or Mehrlich's malt medium are placed in sterilized tap or distilled water. Zoospores were produced only if the water medium was changed at frequent intervals or if air was passed through the liquid. Sporangia are borne terminally on short side-branches of a main hyphal strand, two to three sporangia often being present on a relatively short length of hypha. They are not cut off from the mother hypha by a septum. Sporangia proliferate freely, and as many as five successive structures may be produced. They range in size from 12.8 to 33.6 microns by 16 to 41.6 microns with a mean of 22.4 by 28.8 microns. The number of zoospores formed is associated with the physiology of the parent mycelium, a greater number of zoospores being produced on the more vigorous mycelia.

Free-swimming zoospores are produced in 20 to 30 minutes (occasionally less) after initial vacuolation of the prosporangium. A thin-walled vesicle is extruded into which the protoplasm passes before the swarm spores are differentiated. The protoplasm rotates, back and forth, for several minutes, and then cleavage walls appear. Ultimately the spores are completely formed and at approximately the same time the vesicle bursts and the spores are liberated. The vesicle has never been seen to be initiated at any point other than the apex of the sporangium. Frequently it is initiated as a cylindrical tube which may attain considerable length before inflation occurs. The zoospores are reniform and laterally biciliate. They swim vigorously for 5 to 10 minutes, settle down, round up, and germinate in 15 to 20 minutes after movement has ceased (at 25° to 27° C.). Diplanetism has never been observed. Zoospores (rounded up) measure 9.6 to 16 microns with a mean of 11.2 microns.

Sexual bodies have never been found, either in agar culture or in the cells of diseased taro roots. In the taro root cells, mycelia and irregularly globose or elongated, rectangular-shaped, densely protoplasmic bodies are present. The latter are believed to be prosporangia and produce mycelia, terminated at the surface of the root or root hair by sporangia. In old diseased roots the prosporangia appear as globose, empty cells, with a well-defined wall. They average 22.4 by 24.6 microns with a wall 1.6 microns wide, closely approximating the average for sporangia produced under laboratory conditions.

The results obtained from field tests were largely inconclusive. Chemical treatments of the taro soil do not seem to be worth while and the best method of control appears to be the adoption of good cultural practices, particularly drying and deep plowing of taro land.

Copper sulphate at 100 to 500 pounds per acre, applied before planting, has given no control of *Pythium* sp. Sulphur at 150 and 300 pounds per acre increased soft rot by statistically significant amounts, a result noted last year. Tetrachloroethane at 50 to 300 pounds per acre produced no "loliloli taro" but was of no value in the control of rot. Lime at 100 to 500 pounds per acre had no effect on the incidence of soft rot.

Using various fertilizer combinations applied in different amounts and at different times, it has been shown that the type and amount of fertilizer used and the time of application had no statistically significant effect on soft rot or yield of the taro plant. Exclusion of nitrogen, phosphorus, or potassium from a fertilizer likewise had no effect on the presence or absence of disease or on yield. These results would seem to indicate that the taro soils studied are rich in these three elements due to fertilization of previous crops. (Parris)

Vascular Necrosis of the Taro Corm

This disease, which has never been duplicated in the laboratory, cannot be attributed to a specific causal organism. It is believed to be caused by unfavorable growing conditions in the soil which induce the death of roots; the necrosis is then projected into the interior of the corm by way of the vascular system. Lesions within the corm are characterized by the presence of rings of periderm around the dead tissues; beyond the periderm the tissues (parenchyma) are healthy. Planting material (huli) taken from nonsubmerged soil where vascular necrosis is never found becomes diseased to the extent of 15 to 30 percent when planted in submerged soil. Huli from diseased corms planted in nonsubmerged soil develop only healthy plants. (Parris)

Varietal Resistance to Soft Rot and Vascular Necrosis

Forty-four varieties were planted in two localities on Oahu in submerged taro soil known to be worthless for production of healthy taro. Due to unforeseen circumstances, one plat was harvested prior to collection of data. Data from the second plat showed that the varieties Mana Uliuli, Mana Ulaula, Mana Ulu, Mana Eleele, and Kai Kea are apparently immune to vascular necrosis, while Kai Uliuli, Ulaula Kumu, and Kakakura-ula were very resistant.

While no variety showed less than 10-percent soft rot, the following varieties showed less than 20-percent: Moi, Ohe, Oene, Palaii, Kai Uliuli, Kumu Eleele, and two unclassified varieties. The standard field varieties Piko Uliuli, Piialii, and Piko Kea were severely affected by both diseases. The variety Kai Uliuli apparently combined resistance to both diseases, and gave the highest yield in the plat test. (Parris)

DISEASES OF OTHER CROPS

Ergot of Paspalum

Ergot of paspalum (*Paspalum dilatatum* and *P. orbiculare*), caused by *Claviceps paspali,* was discovered on Maui in the vicinity of Makawao in December 1937. A previous search of this island and also of the island of Hawaii had revealed no diseased plants. The fungus is believed to have been introduced into the Territory on seed of *Paspalum dilatatum* imported from Australia. In April 1938 a third survey showed mature ergots as well as the conidial (sphacelial) or "honeydew" stage in a number of localities on both Maui and Hawaii, and an additional locality was added in July 1938. In table 8 are given the localities where the fungus has been found, with notes on reproductive structures present and the altitude, temperature, and precipitation for each locality.

Germinating sclerotia have not been found in Hawaii, though in some localities temperatures prevail which correspond fairly closely with those

TABLE 8. — Localities in the Hawaiian Islands where *Claviceps paspali* has been found during the period December 1937 to July 1938

Locality	Date	Reproductive structures of fungus present	Altitude	Mean annual rainfall	Temperature fluctuations during a year (approximate)	
			Feet	*Inches*	*Season*	*Degrees Fahrenheit*
Makawao, Maui	December 1937	Sclerotia, conidia	1,500	60 to 70	Winter Summer	59—70 64—86
Parker Ranch—Waimea, Hawaii	April 1938	Sclerotia	3,500	60	Winter Summer	45—80 50—85
Parker Ranch—Waikii, Hawaii	April 1938	Sclerotia, conidia	3,000 to 4,500	Less than 40	Winter Summer	40—78 47—78
Kula, Maui	April 1938	Sclerotia, conidia	4,000	35	Winter Summer	40—78 47—78
Kaupo, Maui	April 1938	Sclerotia	1,100	70	Winter Summer	54—78 60—85
Parker Ranch—Kohala region, Hawaii	July 1938	Sclerotia, conidia	3,500	60	Winter Summer	47—80 50—83

given for New South Wales in Australia where the sexual stage is found[1]. In Hawaii horses feeding on land supporting infected paspalum have shown a condition called "blows" by local ranchers, which appears to be a type of asthma. The animals soon recover if removed to clean pasture but if they are allowed to remain on the contaminated pasture, death may follow. Mules and cattle apparently are not affected. (Parris, Ripperton)

Miscellaneous Plant Diseases

In table 9 is given a list of fungus, bacterial, nematode, and virus diseases noted in the Hawaiian Islands during the past year but not discussed in detail in this report.

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[1] NOBLE, R. J. ERGOT IN PASPALUM. Agr. Gazette New South Wales 47:403-405. 1936.

TABLE 9.—Miscellaneous plant diseases noted in Hawaii from July 1937 to June 1938

Scientific name of disease	Common name of disease	Scientific name of plant host	Common name of plant host
Albugo sp.	Leaf spot (white rust)	*Boerhavia diffusa*	
Bacterium sp. (*woodsii?*)	Leaf spot	*Dianthus caryopyhyllus*	Carnation
Botryosphaeria ribis chromongena	Stem canker and fruit rot	*Eriobotrya japonica*	Loquat
Cercospora lactucae	Leaf spot	*Lactuca sativa*	Lettuce
Cercospora violae	do	*Viola* sp.	Violet
Cercospora sp.	do	*Crotolaria spectabilis*	
Colletotrichum gloeosporioides	Fruit rot	*Annona cherimolia*	Cherimoya
Colletotrichum lagenarium	Leaf spot	*Cucumis sativus*	Cucumber
Colletotrichum nigrum	Fruit spot	*Capsicum frutescens*	Pepper
Colletotrichum phomoides	Fruit rot	*Lycopersicon esculentum*	Tomato
Fusarium sp. (*niveum?*)	Wilt	*Citrullus vulgaris*	Watermelon
Heterodera marioni	Nematode infestation	*Beta vulgaris*	Beet
		Begonia sp.	Begonia
		Capsicum frutescens	Pepper
		Carica papaya	Papaya
		Coleus sp.	
		Cucumis sativus	Cucumber

TABLE 9. — Miscellaneous plant diseases (continued)

Scientific name of disease	Common name of disease	Scientific name of plant host	Common name of plant host
Heterodera marioni (continued)	Nematode infestation	*Daucus carota* var. *sativa*	Carrot
		Tephrosia vogelii	
Leptothyrium sidae	Leaf spot	*Sida rhombifolia*	Sida
Peronospora parasitica	do	*Brassica pekinensis*	Chinese cabbage
Phyllostictaa medicaginis	do	*Medicago sativa*	Alfalfa
Phyllosticta sp.	do	*Viola* sp.	Violet
Phytophthora parasitica[1]	Blight	*Lochnera* (*Vinca*) sp.	Periwinkle
Ravenelia siliquae	Rust	*Acacia farnesiana*	Klu
Rhizoctonia solani	Rot	*Lactuca sativa*	Lettuce
Rhizoctonia sp.	Root rot	*Cynodon dactylon*	Bermuda grass
Rhizopus sp.	Fruit rot	*Ficus carica*	Fig
Sclerotium rolfsii	Wilt and root rot	*Cajanus cajan*	Pigeonpea
		Solanum melongena var. *esculentum*	Eggplant
Septoria sp.	Leaf spot	*Centella asciatica*	
Sphacelotheca monilifera	Smut	*Heteropogon contortus*	Pili grass
Uromyces proeminens	Rust	*Euphorbia prostrata* (*serpyllifolia*)	
Ustilago bromivora	Smut	*Bromus catharticus*	Bromegrass
Ustilago utriculosa	do	*Polygonum glabrum*	

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[1] Erroneously reported as *P. colocasiae*.

ENTOMOLOGY

The work of the department during its first year has, perforce, consisted chiefly in developing a catalog and a reference collection of insect species of the Islands, securing detailed information on those insects which occur on local crops, and studying physical conditions and agricultural practices which are favorable or unfavorable to insect survival. The reduction of economic loss from these pests will be sought through chemical and biological control of the respective insect species, introduction of more resistant varieties of crops, restriction of the planting period of particular crops, and utilization of systems of crop rotation.

The following insects (table 10) rank as the most serious pests on which observations have been made to date: (Holdaway)

TABLE 10.—Insect pests of crops in Hawaii

Scientific name	Common name	Hosts
Adoretus sinicus	Chinese rose beetle	String beans
Anthonomus eugenii	Pepper weevil	Peppers
Aphis gossypii	Cotton or melon aphid	Cucurbits, potatoes
Aphis maidis	Corn aphid	Corn
Cyrtopeltis varians (*Engytatus geniculatus*)	Tomato bug	Tomatoes, potatoes, eggplant
Dacus cucurbitae	Melon fly	Cucurbits, tomatoes, string beans
Empoasca solana	Potato leaf hopper	Various crops
Epitrix parvula	Flea beetle	Solanaceous crops
Heliothis armigera	Corn earworm	Corn, tomatoes, peppers, eggplant, tobacco
Macrosiphum gei (*solanifolii*)	Green potato aphid	Potatoes, tomatoes
Phthorimaea operculella	Tuber moth	Potatoes
Pontia rapae	Cabbage worm	Cabbage and other brassicae
Pycnoderes quadrimaculatus	Bean capsid	Beans
Various species	Mites	Peppers, eggplants, papaya, potatoes, asparagus, litchi, and coffee

CHEMISTRY AND SOILS

COFFEE INVESTIGATIONS

Rainfall and Coffee Yields

A statistical study of the relations between rainfall and coffee production in the Kona District may be summarized as follows:

1. Two distinct periods of heavy rainfall and one period of markedly light precipitation occurred during the years 1901 to 1936.

2. Monthly distribution figures indicate that the rainy season consistently came during the summer, while the winter months had uncertain rainfall with low mean precipitation.

3. Much of the variability in annual production may be ascribed to fluctuations in rainfall occurring from February to June during the years in which fruiting wood is produced.

Composition of the Coffee Trees

The fertilizer experiment at the Fukuda farm, which has been conducted for 8 years, afforded an excellent opportunity to study the effects of fertilizers on the composition of the coffee tree. For the purposes of this investigation the trees from the check, nitrogen-fertilized, and completely fertilized plats were sampled and the plant parts segregated into roots, bark, fruit, fruiting laterals, and new lateral growth (new laterals and leaves on new laterals).

Some of the points of interest brought out by the analyses of these samples are summarized as follows:

1. Nitrates in abundance were found in all tree parts studied. The largest accumulation of nitrates resulting from nitrogen fertilization occurred in the new lateral growth.

2. The application of phosphates resulted in a general increase in total phosphorus throughout the tree.

3. The largest percentages of potassium were found in the fruit and new lateral growth. The application of potassium in fertilizer caused a marked increase in the amounts of potassium in all parts of the tree.

4. The starch content of the new lateral growth of the potassium-fertilized trees was about twice as great as in those trees which received no potassium. However, there were no appreciable differences in the starch content of the storage tissues of either the potassium-treated or untreated trees.

Coffee Quality Studies

The price commanded by a shipment of coffee is dependent upon many factors, among which are: (1) Reputation of country or district in which the coffee was grown; (2) variety; (3) grade according to size and color; (4) taste or cupping quality. An experiment was conducted to determine what factors influenced the quality of coffee, particularly the cupping quality. All cupping tests reported below were performed by experts in San Francisco.

1. Methods of processing cherry coffee were studied to determine whether the small home processing plants were satisfactory. In processing coffee in Kona, the pulp is first removed from the seed or bean by a specially designed machine called a pulper; the beans are fermented to loosen a gelatinous coating which is then removed by washing; the parchment coffee is spread out to dry, and milled later to remove the parchment and silver skin. The results of experiments on the fermentation, washing, and drying steps have shown that no measurable change in the quality of coffee is effected by improved methods.

2. In order to determine whether location within the district had any effect on coffee quality, samples of coffee cherries were collected from high and low elevations and from the north, central, and south sections of Kona, and processed under standard conditions. Cupping tests on these samples did not reveal any gradations which would cause a price differential.

3. In a study of the effects of fertilizers on coffee quality, samples of cherries from trees heavily fertilized for 7 years and from adjacent ones which had received no fertilizer over the same period were processed under standard conditions. A cupping test revealed only fractional differences to which no significance was attached. Further, a cupping test comparing standard field-grown coffee with wild "Hawaiian coffee" grown under kukui trees showed no differences of economic importance.

4. A wide variation usually occurs in the ripeness of cherries on a single tree, and the practice has generally been to pick only the fully ripe cherries. However, to reduce the cost of producing coffee, as many cherries as possible should be picked at one time, which would entail the picking of greener cherries. For the purpose of determining the effect of the ripeness of coffee cherries on the quality of the coffee, a bag of commercially picked cherries was separated by hand into the following three groups:

1. Green ripe—with green or yellow coloring to their skins.
2. Hard ripe—with red skins but still firm.
3. Soft ripe—soft and completely red (usually a darker red than the hard ripe cherries).

The separates were processed under standard conditions. There were no apparent differences in the appearance of the processed coffee, and a cupping test showed no distinguishable differences between samples at various stages of maturity. (Dean, Yoshida)

SOIL INVESTIGATIONS

Soil Nitrogen Studies

Mineralizable nitrogen, which for the purpose of this study is defined as the organic soil nitrogen converted into inorganic nitrogen (ammonia and nitrates) during a crop period, has been under investigation.

Changes in nitrate content of soils wetted to optimum conditions, supplied with ample minerals, and incubated at 30° C., were traced over a period of 10 months. The study showed the existence of two definite phases of mineralization. A rapid initial phase of nitrogen release which lasted about 3 weeks was followed by a slow constant phase which continued for the remainder of the study. Subsequent experiments showed that during the first phase there was a release of from 2 to 30 milligrams of nitrogen per 100 grams of soil, while during the second phase the releases amounted to from 0.25 to 2 milligrams of nitrogen per 100 grams of soil over an equal period.

Using a representative series of soils, a close relationship was found between the amounts of mineralizable nitrogen obtained after 3 weeks' incubation under optimum conditions and the amounts of nitrogen taken up by Sudan grass grown in pots for 70 days (see fig. 5).

A statistical study of mineralizable nitrogen, total nitrogen, total carbon, and the carbon-nitrogen ratio revealed no significant relationships.

Attempts to determine the nature of the soil-nitrogen compounds which yield mineralizable nitrogen have met with little success. Extracting soils with solutions of various strengths of alcohol, hydrochloric acid, acetic acid, sodium chloride, and acidified sodium chloride, returning the soils to their original pH, and inoculating them with water extracts of the original soils did not decrease the amounts of mineralizable nitrogen which the soils yielded.

When amino acids and proteins were added to soils, their nitrogen was completely mineralized. However, the fresh plant material from

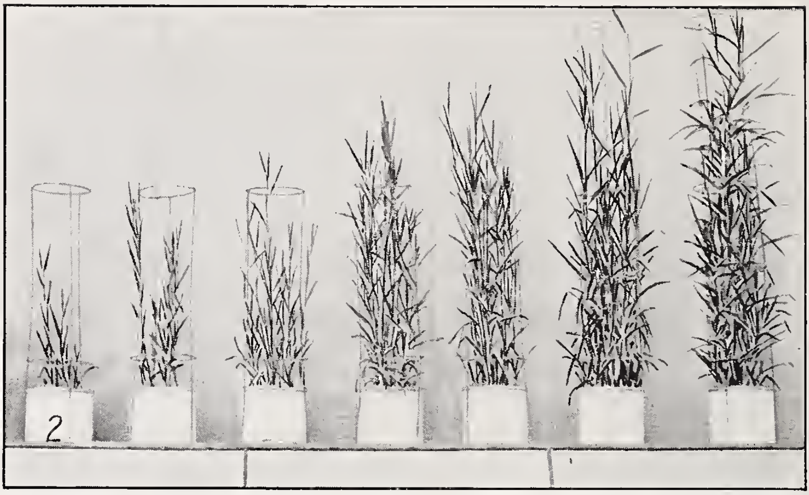

FIGURE 5.—Sudan grass growing in a series of soils containing mineralizable nitrogen (in mg per kg of soil) as follows, from left to right: 21, 30, 40, 77, 62, 107, 144.

which these are extractable did not increase the mineralizable nitrogen in the soils. Hence, the mineralizable nitrogen appears to be related to the carbon-nitrogen balance of certain readily available organic materials present in soils. (Fukunaga, Dean)

Soil Phosphorus Studies

The effects of soil pH on the relative proportions of alkali-soluble and acid-soluble forms developed from tri-calcium phosphate added to the soil has been under consideration. These studies were based on the assumption that alkali extraction removes the phosphorus from the iron and aluminum phosphates of a soil while an acid extract of a previously alkali-extracted soil removes the phosphorus from the tri-calcium phosphates and apatites which were not attacked by the alkali. These studies may be summarized as follows:

1. Phosphorus added to acid soils tended to accumulate in an alkali-soluble form.

2. Phosphorus added to neutral or calcareous soils tended to accumulate in an acid-soluble but alkali-insoluble form.

That part of the total soil phosphorus which was not removed by an alkali extraction followed by an acid extraction comprised in many instances the largest fraction of the total soil phosphorus—about 40 percent. Studies on the possible composition of this fraction, using lavas, volcanic ash, and soils of different ages and states of decomposition indicated that this fraction of the soil phosphorus was held either as an inclusion within the primary minerals or as a substitution in the crystal lattice of the soil minerals. (Dean)

The Calcium-Magnesium Ratio of Some Hawaiian Soils

Replaceable calcium and magnesium determinations on a series of Hawaiian soils showed a range in calcium-magnesium ratios of from 0.5 to 14. The soils having the low ratios were those found in dry, low-lying areas which at one time had been under salt water. These soils were usually above pH 7, dark-colored, and puddled. The soils having the high ratios were commonly found in higher, more humid areas.

A duplicated pot experiment was undertaken for the purpose of studying the effect on the growth of plants of changing the calcium-magnesium ratios of typical soils. The following three soils were used:

	Calcium-magnesium ratio
1. Crozier's farm, Koko Head, Oahu	0.5
2. Poamoho farm, Waialua, Oahu	10.5
3. Kato's farm, Waimea, Hawaii	11.8

The growth of Sudan grass on the Crozier farm soil was not affected when calcium sulphate was added in order to increase the ratio.

Additions of magnesium sulphate to the Poamoho farm soil which reduced the ratio from 10.5 to 6 increased the dry weight of Sudan grass grown from 63 to 81 grams per pot.

Additions of magnesium sulphate to the Kato farm soil which reduced the ratio from 11.8 to 4 increased the dry weight of lettuce grown from 25 to 37 grams per pot. The lettuce grown on the magnesium-treated soils also appeared to head much more rapidly. (C. Lyman, Dean)

The Carbide Method for Determining Soil Moisture

Studies were undertaken on the applicability of the calcium-carbide method for moisture determination as a simple rapid means of determining soil moistures in the field. Soils were shaken with an excess of finely ground calcium carbide in a steel bomb and the increase in pressure measured. For accurate laboratory calibration a mercury manometer was utilized, while for routine determinations a 30-pound steam gauge sufficed. Studies using soils ranging in moisture contents from the maximum field capacity to below the wilting coefficient showed that for each soil there was a constant difference between the moisture contents as determined by oven drying and by the carbide method, ranging from 4 to 7 percent. These experiments indicate the utility of the calcium-carbide method as used if the critical soil-moisture constants have been predetermined on the same basis. (Fukunaga, Dean)

Quick Soil Testing

During the past year the department volunteered to analyze any soil samples submitted by farmers or other interested parties. The available phosphoric acid, potash, calcium, and magnesium and the pH were determined with the Truog-Hellige soil tester. From the lack of response, it would appear that the independent farmers are not as yet greatly interested in using soil analyses as a guide to their fertilizer practices. The samples received from farmers were, for the most part, submitted through the Agricultural Extension Service. Thirty-one samples were analyzed from Oahu during the past year, and only 26 from all the other islands. Fifty-two samples submitted by other departments of the experiment station brought the total number of analyses to 111. (C. Lyman, Dean)

SOIL PHYSICS

Temperature as a Factor in Surface-Energy Relationships

Continued work with a local lateritic soil and a clay loam imported from Wisconsin emphasized the importance of certain thermal phenomena in critical studies of soil-moisture—surface-force relations.

When the conventional moisture-content—surface-force curve was located by bringing the moisture contents of the two soils into equilibrium with relative humidities established by saturated solutions of chemically pure salts, it was noted that the position of the curve in the axes depended upon the temperature at which the equilibrium was established. Over a wide range of humidities, the soil moisture content decreased as the temperature increased[1].

Another effect of the influence of temperature upon surface energy was noted in a critical study of heat of wetting. Samples of the Superior clay loam containing 2.01-percent moisture were sealed in small glass bombs. The bombs were placed in the loaded calorimeter, brought into thermal equilibrium with the system, and smashed by means of a blade extending through the cork. Heat evolution was measured as usual. The results of one of many series of tests are given in table 11.

Table 11. — Results of heat-of-wetting determinations made at different temperatures (soil: Superior clay loam)

Temperature of determinations	Moisture Content	Number of determinations	Heat of wetting per gram of dry soil
Degrees C.	*Percent*		*Calories*
8	2.01	11	0.99 ± 0.05
40	2.01	10	.69 ± .04

Similar results were secured with the lateritic soils and with soils at other moisture contents[2].

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[1] Wadsworth, H. A. THE EFFECT OF TEMPERATURE UPON THE MOISTURE-CONTENT—SURFACE-FORCE CURVE. In press.

[2] Wadsworth, H. A. A STUDY OF SOME FACTORS INFLUENCING THE HEAT OF WETTING OF SOILS. In press.

HEAT OF WETTING AS RELATED TO SOIL-MOISTURE CONTENT

Although the determination of the heat of wetting of a soil or a soil colloid is ordinarily made with oven-dry material, it has been found that measurable heat is evolved when soils much wetter than this are used. Repeated observations with several soils indicate that the relationship between original soil-moisture content and the heat evolved upon saturation may be expressed as follows:

$$H = Ke^{-cx}$$

where H = heat of wetting in calories per gram of soil at moisture content x

K = a constant (the heat in calories evolved in saturating 1 gram of oven-dry soil)

c = a constant varying with the nature of the material

e = base of natural logarithms.

The great effect of small variations in the initial moisture content upon the measured evolution of heat, as suggested in the equation given, was determined experimentally, and it was shown that great care in the manipulation of dry soils is imperative if reliable heat-of-wetting figures are to be secured. For example, the exposure of oven-dried soils to the open air for the short time required to load the calorimeter in the conventional manner often results in water adsorption to such an extent that the resulting heat of wetting is significantly reduced. The bombs mentioned above were originally designed to prohibit this premature adsorption[1].

THE RATE OF TEMPERATURE CHANGE IN SOILS

The results given for the heat-of-wetting observations and a consideration of the basic equation ordinarily used in quantitative studies of energy relations in soils led to the conclusion that some change in energy should be apparent if the temperature of the soil is changed.

Samples of carefully prepared soils of known moisture contents were packed around the bulb of a thermometer in thin-walled test tubes. The tubes were brought to a known temperature and then quickly plunged into a bath of different but constant temperature. The rate of change of temperature as related to the thermal gradient is then a qualitative measure of the thermal properties of the sample. Samples free from changes in energy relationships should follow the conventional law of cooling or heating:

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[1] WADSWORTH, H. A. SOME THERMAL PHENOMENA IN A SELECTED HAWAIIAN SOIL. Soil Sci. 45:251-262, illus. 1938.

$$T_2 = T_1 e^{-ct}$$

where T_2 = original difference in temperature between soil mass and water bath

T_1 = difference in temperature at time of observation

t = elapsed time since beginning of observation

e = base of natural logarithms.

Oven-dried soils, dry silica sand, and pure water followed this law exactly. With soils carrying small amounts of water the observed rise of soil temperature in the case of a cold soil, and the fall of temperature in the case of a warm soil were slower than the law demanded. It is evident that in the case of a cooling soil the withdrawal of a unit amount of heat is associated with the internal evolution of an increment of heat in the soil mass. Since this additional heat must find its way into the outside reservoir, the attainment of thermal equilibrium is delayed. The picture is reversed when a cool soil is warmed. In this case heat flows from the reservoir into the soil. Since the attainment of equilibrium in this case, too, is delayed, it appears that part of the energy introduced into the system as heat finds expression in some other form, probably pressure, and the measured rise of temperature is delayed[1].

[1] WADSWORTH, H. A. STUDIES IN THE RATES OF TEMPERATURE CHANGES IN SOILS AT VARIOUS MOISTURE CONTENTS. In press.

AGRONOMY

SWEET CORN

Breeding and Selection

Three generations of sweet corn were grown during the past year. Distinct progress was noted in the development of a uniform type of the variety U. S. D. A.-34 by controlled crosses between selected plants. Several of the progeny showed complete absence of purple anthocyanin color.

Many of the first-generation progeny of self-pollinated U. S. D. A.-34 grew to a height of nearly 10 feet, evidencing unusual vigor for an inbred variety. However, much segregation occurred.

The progenies of several hybrid varieties from the mainland, backcrossed to U. S. D. A.-34 for three generations, showed improvement over the parents at each successive backcrossing, particularly with respect to resistance to corn mosaic. In vegetative vigor and size of ears the backcrosses appeared superior to U. S. D. A.-34, which is considered a rank-growing sweet corn with very large ears.

Third generation backcrosses of Golden Bantam and Narrow Grain Evergreen to Guam showed promise. The ears were exceptionally large, and a number of plants each had two well-formed ears. Practically no mosaic was evident in these hybrids.

From field observations on the crops planted in April, July, and November, no differences in average size of ears were noted. Damage from earworm was far less in the November planting than in either of the others, although the corn matured a week later than the spring or summer planting. The two last-mentioned crops made the best growth, but the fall crop was satisfactory.

Chemical Analyses

Analyses were made of two samples of U. S. D. A.-34 sweet corn, immediately after they were harvested, and at 4-, 8-, 24-, and 48-hour intervals, to determine the effect on corn of storage under refrigeration (10° C.) and at room temperature (22° to 27° C.). Figure 6 illustrates graphically the slow loss of sugar in a refrigerator as compared with the rapid loss when the corn was held at room temperature. The ears stored at room temperature lost 45 percent of the total sugar (on a wet basis) in the first 24 hours, but only about 4 percent during the next 24 hours.

The ears stored under refrigeration lost only 9 percent of the total sugar during the first 24 hours, and 12 percent during the following 24 hours.

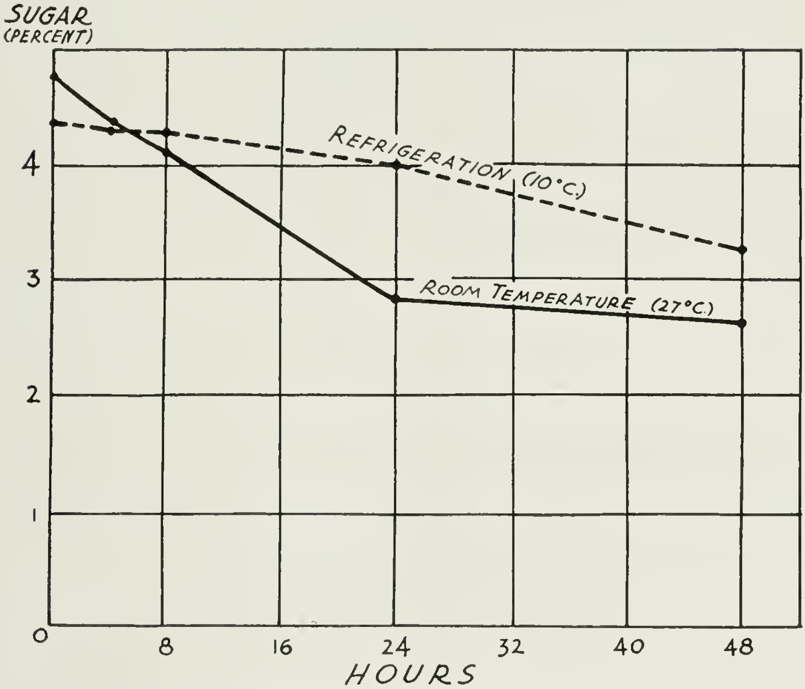

FIGURE 6. — Loss of total sugar (on wet basis) of U. S. D. A.-34 tropical sweet corn stored under refrigeration and at room temperature

SWEETPOTATOES

Spacing and Variety Tests

Combined spacing and variety tests of five promising seedling varieties, together with Yellow Yam and Nancy Hall varieties, were conducted at Waipahu, Oahu and at Kohala, Hawaii. Three spacings within a row, namely, 9-inch, 12-inch and 15-inch, were replicated twice in plats 18 by 7 feet in size. The experiments were harvested 6 months after planting—the Waipahu test in August and the Kohala test in November, 1937.

A comparison of results at the two localities is given in table 12. It will be noted that the varieties reacted similarly in the two localities.

The yields of the Kohala test were incomplete, but the Waipahu test could be analyzed statistically. The analysis of variance indicated no significant differences in yield due to spacing or to the interaction of spacing

TABLE 12. — Comparison of mean yields of sweetpotato varieties grown at Waipahu and at Kohala

Variety	Mean yield per acre (Waipahu)	Mean yield per acre (Kohala)
	Tons	*Tons*
35.5 (seedling variety)	16.08	13.68
Yellow Yam	12.91	14.32
35.14 (seedling variety)	12.05	11.98
35.9 do	11.67	10.95
35.23 do	10.37	11.06
35.19 do	8.26	6.57[1]
Nancy Hall	5.24	3.80
Standard error of difference between two means	1.19	

[1] Mean yield calculated from only four plats; others from six plats.

and varieties, but significant differences among the varieties. The yield of seedling variety 35.5 was significantly higher and that of Nancy Hall significantly lower than the yields of all other varieties.

Evaluation of Quality

Tests were made of the quality of the baked potatoes, judged on the bases of color, texture, sweetness, and flavor. The results of these tests, together with evaluations of the varieties as to yield and shape, appear in table 13.

The foregoing evaluations of the new seedling varieties and the commercial varieties indicate progress in development of sweetpotatoes combining desirable yield, shape, and cooking quality. (Takahashi)

NAPIER GRASS INVESTIGATIONS

Strain Testing of Napier-Merker Hybrids

An experiment designed to compare the green forage yields and certain botanical and agronomic characters of standard Napier grass (*Pennisetum purpureum* Schum.) and Napier grass crossed with Merker grass (another strain of the same species) was concluded during the past

TABLE 13. — Evaluation of seedling varieties of sweetpotato on the bases of yield, shape, and quality

Variety	Yield	Shape	Cooked quality	General rating
35.5	*Good*[1]	Fair	Fair	Fair
Yellow Yam	Good	Poor	Poor	Poor
35.14	Good	Good	Good	Good
35.9	Good	*Good*	Good	*Good*
35.23	Good	Good	Good	Good
35.19	Poor	Fair	Fair	Fair
Nancy Hall	Poor	Poor	*Good*	Fair

[1] The italicized variety is high ranking in that classification.

year. The test included a total of 15 harvest over 3 years.

According to the analysis of variance there were no significant differences among the strains for the 3-year period, and there was no interaction between season and strains.

Results of chemical analysis of the whole forage showed no marked differences among the strains or between the strains and the standard. Field observations indicated more rapid recovery after harvesting for the hybrid strains; at time of harvest the latter were usually 2 feet taller than the standard Napier (see fig. 7). Tillering was much better in the strains although the shoots were somewhat open in growth, and the culms were thinner and more glabrous.

Frequency of Cutting of Napier Grass

This experiment, reported last year, was concluded in October 1937, after a total of 24 harvests for the shortest cutting interval (6 weeks) and 10 for the longest (14 weeks). Final yields of green forage and protein contents of the total harvests and of the palatable portions are shown in figure 8. Total yields of green forage were significantly higher for the 10-, 12-, and 14-week intervals than for the 8- or 6-week interval. However, as reported last year, the decrease in palatable portion with greater age of the plant more than offset this advantage so that, on the bases of both palatable portion and protein content, an 8-week interval was optimum for cutting at a low elevation where irrigation and fertilization were possible.

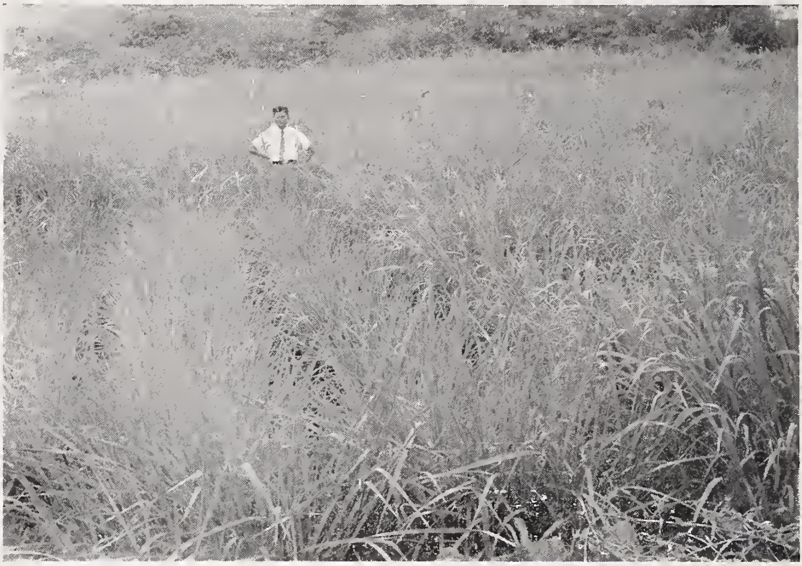

FIGURE 7. — Napier-strains test — Standard Napier in the left foreground

Field observations showed that the stand of the 6-week plat was irregular and the stools were weak, while those of the 8-week plat and longer intervals were normal in vigor. During the winter months when growth is slower, a cutting interval of 10 weeks might prove desirable. (Ripperton, Akamine)

GERMINATION AND STORAGE OF SEEDS

Control of Humidity and Temperature

Viability studies of the seed of soybeans, garden beans, corn, alfalfa, lettuce, rice, and a grass (*Pennisetum ciliare*) were concluded (see annual report for 1937). After 27 months of storage at room temperature, corn and alfalfa maintained high viability at relative humidities of 15, 30, 45, and 60 percent; rice remained viable at humidities of 15, 30, and 45 percent but gave zero germination after storage at 60 percent. Seed of the other species tested gave evidence of very irregular germination when standard methods of determination were used. The irregularity appeared to be related to the long period of storage. The results from germination tests of soybeans were entirely unreliable.

Tests of seed stored at various temperatures without control of humidity indicated that all species retained approximately initial germination

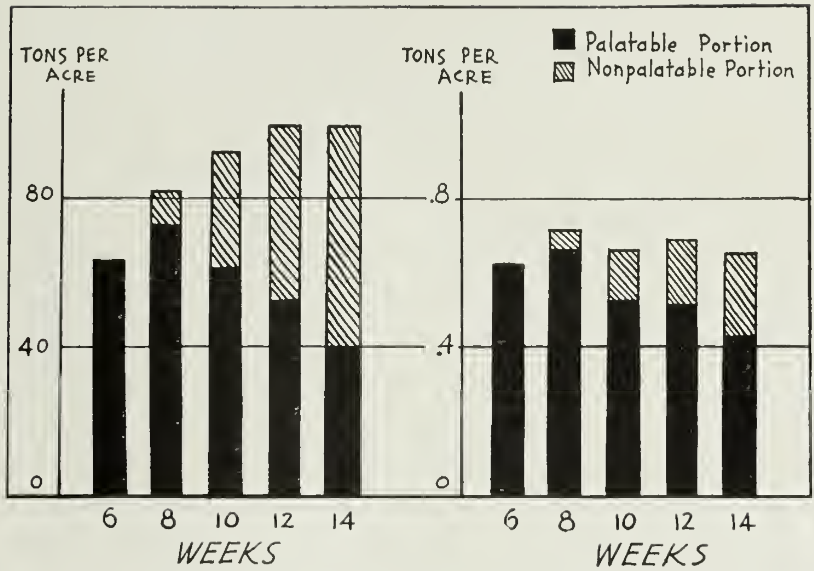

FIGURE 8. — Left, mean annual yields of green forage; right, protein contents of Napier grass (on air-dry basis) with various cutting intervals.

after 27 months' storage at 45° F. At higher temperatures or in air-tight containers the results were not so satisfactory.

Germination of Treated Koa Haole Seed After Storage

The seed of koa haole (*Leucaena glauca*), as previously reported, normally gives low germination. Cutting the seed coat with a knife has resulted in 100-percent germination, but such a practice is not feasible for large plantings. It has been demonstrated that treatment with sulphuric acid or hot water will also induce germination. A test was designed to determine the viability of the treated seed. In order to induce germination, the seed coats of the untreated or control lot were cut just prior to planting. Results are given in table 14.

The table indicates that treatment of koa haole seed with sulphuric acid, with subsequent drying before storage, may be a practical procedure for deferred large-scale plantings. Hot water was not so efficient as sulphuric acid in inducing germination or maintaining viability. (Akamine, Ripperton)

TABLE 14. — Germination of treated seed of koa haole after various periods of storage in open containers at room temperature

Treatment	Initial germination	Germination after storage period of—			
		3 months	6 months	12 months	20 months
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Sulphuric acid (95%) for 13 minutes at room temperature	100	98	99	98	93
Hot water for 20 minutes at 158° F.	74	75	67	54	41
Control (seed coat cut prior to planting)	100	96	95	100	97

PASTURE GRASS INVESTIGATIONS

Pasture Survey

A vegetative survey of pasture areas begun during the previous year was extended to additional ranches. In organizing the data, special attention was given to ecological factors. The extremes of rainfall and altitude which occur on Hawaiian ranges produce definite plant zonation, generally conforming to isohyetal lines. Five climatic zones more or less typical of the larger areas of the Territory have been tentatively adopted to conform to plant zones, after the Jones-Bellaire modification of Thornthwaite's system of classification[1].

Zone A—Very low rainfall (less than 20 inches), very hot; low-lying areas bordering the coast line on the lee side. Dominant pasture species are algaroba (*Prosopis chilensis*), *Chloris inflata,* and pili grass (*Heteropogon contortus*).

Zone B—Low rainfall (between 20 and 35 inches), hot; the zone just above Zone A on the lee sides. Dominant species are lantana (*Lantana camara*), ilima (*Sida fallax*), uhaloa (*Waltheria indica*), koa haole (*Leucaena glauca*), and cactus (*Opuntia megacantha*).

Zone C—Moderate rainfall (from 35 to about 60 inches), moderate temperature; chiefly the uplands, especially the table lands between mountain ranges. Dominant species are Bermuda grass (*Cynodon dactylon*) and rattail grass (*Sporobolus elongatus*).

Zone D—Moderate rainfall, cold; usually above 7,000 feet, and found mostly on Hawaii; too high and dry to be of much value for grazing.

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[1] JONES, S. B., AND BELLAIRE, R. THE CLASSIFICATION OF HAWAIIAN CLIMATES. Geog. Rev. 27. 1937.

Zone E—High rainfall (60 inches or above), moderate temperature; constitutes chiefly the windward slopes of the several islands. The dominant species are guava (*Psidium guajava*), Hilo grass (*Paspalum conjugatum*), and ricegrass (*Paspalum orbiculare*).

The ranches of Hawaii are usually strips of land extending from sea level to a considerable altitude so that more than one, and often four, of the five zones are represented on a single ranch. Maps of the several islands have been prepared on which the boundaries of the principal ranches are marked. Superimposed are the approximate limits of the climatic zones.

Climatic phases other than rainfall and temperature which have an important bearing on vegetation are relative humidity, wind velocity, and cloud blanket. In general, soil types are correlated with climate and plant association. (Ripperton, Hosaka)

Grass Species Established on Hawaiian Ranges

As a part of the pasture survey, collections were made of all the grasses established on the range. These have been identified and a manuscript prepared for publication in which 103 grass species and varieties are illustrated and described. An additional 136 grasses are listed and indexed as to origin and date of introduction into Hawaii.

This survey shows very strikingly the paucity of native grasses and the importance of introduced species on the Hawaiian ranges. Africa has been by far the most important source of tropical grasses and Europe of temperate species. (Whitney, Hosaka, Ripperton)

New Species

A collection was begun of strains of temperate species which have become established in local pastures over a period of 10 years. These include white clover (*Trifolium repens*), yellow sweet clover (*Melilotus officinalis*), hop clover (*Trifolium procumbens*), black medic clover (*Medicago lupulina*), bur-clover (*M. denticulata*), ryegrass (*Lolium* sp.), cocksfoot (*Dactylis glomerata*), and velvet grass (*Holcus lanatus*). This method of securing strains of special adaptability through natural selection has proved very successful in New Zealand and elsewhere. It is commonly noted that introductions of certain species are distinctly less vigorous in the cooperative grass gardens than volunteer plants of the established strain.

New accessions during the year include three strains of Rhodes grass (*Chloris gayana*), five strains of ryegrass (*Lolium* sp.), and one strain each of white clover, kikuyu grass (*Pennisetum clandestinum*), *Trifolium* *lodigensis, Brachiaria brizantha, B. ciliantissima,* and *Eragrostis lehmanniana.*

Marked variability has occurred within a number of introductions, including *Andropogon scoparius, A. furcatus, Panicum virgatum,* and *Desmodium discolor.* These are being segregated for trial and increase.

Adaptability Trials

Grass gardens have been installed at the Pensacola Street Station, Oahu, 200 feet altitude, with 135 species; Poamoho Farm, Oahu, 650 feet altitude, with 115 species; and Haleakala Substation, Maui, 2,200 feet altitude, with 125 species. Periodic notes are being taken at each location as to growth habits, adaptability to the varying climatic zones, yield, and probable forage value.

Arrangements have been made with a number of ranches to establish small trial gardens with facilities for clean culture and special care. The rancher will thus become familiar with a grass before deciding whether he wishes to increase or discard it, and will have planting material available for trials elsewhere on the ranch. Detailed results will not be recorded, but occasional checks will be made as to the ultimate success or failure of a species. This plan, with active cooperation on the part of ranchers, permits of the widespread use of new material as soon as it is available.

Palatability Trials

Whether or not a grass is palatable is difficult to establish. A feed may be eaten at one time and not at another depending on other feeds available or on the stage of growth of the grass itself. Relative palatability is a composite of actual flavor, nutritive value, and physical characteristics such as succulence, tenderness, and stemminess. An experiment was conducted to determine quantitatively the differences in palatability of grasses by measuring the average daily intake of a grass which served as the sole source of feed. Eight steers in stalls were used in the test. The average daily consumption of each steer for Napier grass (used as a standard) was determined at the beginning and end of the experiment. Eight other species were fed for periods ranging from 5 to 8 days, or until the intake curve reached a constant level. The results are shown in table 15, with dry matter intake expressed as percentage of intake of Napier grass. The data are not always consistent and the number of animals used was too small for exact comparison. However, there is a spread of more than 100 percent between Hilo grass, the poorest, and *Digitaria milanjiana,* the grass with highest acceptance when no other feed was available. Chemical analyses of the feeds indicated that no single constituent appeared to determine the amount ingested. This method, while admittedly artificial, appears to offer some promise as a method of measuring palatability, particularly if consideration is also given to selectivity tests. (Lyman, Ripperton)

TABLE 15.—Daily intake of grasses by steers, the grass being available to the animal in excess and constituting the only source of feed[1] (results expressed as dry-matter percentage of Napier grass)

Animal No.	*Pennisetum purpureum* (Napier grass)	*Sorghum vulgare sudanense* (Sudan grass)	*Chloris gayana* (Rhodes grass)	*Paspalum conjugatum* (Hilo grass)	*Pennisetum clandestinum* (Kikuyu grass)	*Digitaria milanjiana*	*Tricholaena repens* (Natal redtop)	*Cynodon dactylon* (Bermuda grass)	*Paspalum urvillei* (Vasey grass)
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	100		114		125	167			
2	100		97		116		118		
3	100		121		122	178			
4	100		116		130		186		
5	100	145		102				186	
6	100	124		76				130	
7	100	93		75					103
8	100	108		85					105
Average	100	118	112	85	122	173	152	158	104

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[1] Due to inability to estimate increasing consumption of Sudan grass by the animals, this grass was never available to excess.

ANIMAL HUSBANDRY

Dairy-Cattle Feeding Experiments

Algaroba-Bean Meal for Dairy Cows

In a second 12-week experiment with eight Holstein cows on the value of algaroba-bean meal (*Prosopis chilensis*) as a feed for dairy cows, a control ration containing 45.4 percent pineapple bran, 36.4 percent soybean-oil cake meal, and 18.2 percent cane molasses was compared with an experimental ration containing 40 percent algaroba-bean meal, 10 percent pineapple bran, 30 percent soybean-oil cake meal, and 20 percent cane molasses. The average daily milk production for cows on both rations was 23.8 pounds; the average butter-fat content was only slightly higher for the cows fed the control ration (3.54 percent as compared to 3.47 percent). These results indicate a greater value for the algaroba-bean meal ration than was established in a similar test last year.

Sudan Grass Versus Panicum Grass as Roughage for Dairy Cattle

In a fourth and concluding 12-week experiment with eight cows, completed during the past year, Sudan grass was 9 percent more palatable and the cows produced 5.5 percent more milk than when panicum grass was fed. These results are in general agreement with three previous experiments conducted at this station. The four tests are summarized in table 16.

As an average of the four trials, milk production was 7.3 percent higher and consumption of roughage was 12.2 percent greater when Sudan grass was fed. While these average differences are small, they were consistent in every trial.

In the last two of the above trials, grasses were cut in ensilage cutter before feeding, and analyses of the grasses fed each day were made. The averages of these analyses are shown in table 17.

The two grasses are rather similar in composition. The superiority of the Sudan grass lies in its greater palatability, which brings about higher roughage consumption and results in higher milk production. (Henke, Goo)

Rhodes Grass Versus Sudan Grass as Roughage for Dairy Cattle

In a 12-week double-reversal experiment with six cows, Rhodes grass was as satisfactory a roughage as Sudan grass, although the amount

TABLE 16. — Average milk production, butter-fat content, weight, and feed consumption on Sudan and panicum grasses

Test	Average daily milk production	Average butter fat	Concen-trates fed daily	Green roughage consumed daily	Average live weight	Roughage consumed per pound of milk produced
Green Sudan grass	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	20.4	3.83	12.0	48.0	1,024	2.35
2	24.0	4.40	14.6	64.0	973	2.67
3	24.4	3.85	15.0	49.8	973	2.04
4	30.9	3.35	18.7	44.7	1,047	1.45
Average	24.9	3.86	15.1	51.6	1,004	2.13
Green panicum grass						
1	18.6	3.73	12.1	42.0	1,013	2.26
2	22.0	4.39	14.6	57.0	970	2.59
3	23.1	3.97	15.1	43.9	987	1.90
4	29.3	3.32	18.7	41.1	1,047	1.38
Average	23.2	3.85	15.1	46.0	1,004	2.03

TABLE 17.—Comparison of composition of Sudan and panicum grasses

Test No.	Green feed dry matter	Calculated to a water-free basis				
		Crude Protein	Ether extract	Nitrogen-free extract	Crude fiber	Ash
Sudan grass	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
3	29.0	6.65	1.42	46.72	35.15	10.06
4	25.2	7.07	1.21	44.71	36.71	10.28
Average	27.1	6.86	1.32	45.72	35.93	10.17
Panicum grass						
3	30.2	7.02	1.47	43.66	37.05	10.80
4	25.9	5.68	1.05	45.37	36.39	11.50
Average	28.0	6.35	1.26	44.52	36.72	11.15

consumed was less (0.92 lb. Rhodes grass and 1.47 lb. Sudan grass consumed per pound of milk produced). Rhodes grass, however, is lower in moisture content so that the dry-matter intakes of the two grasses were similar.

The Sudan grass used in this experiment was higher in moisture content and, on a dry basis, materially higher in crude protein than that in previous experiments. Although this grass was cut from the regular fields at what appeared to be the same stage of maturity as in previous tests, the analyses suggest that it was less mature. Another trial comparing these grasses is now in progress. (Henke)

BEEF-CATTLE FEEDING EXPERIMENTS

Value of Molasses and Protein Supplements

A second experiment was conducted at Kapapala Ranch to determine the value of cane molasses, soybean-oil meal, and fish meal as supplements to various pasturages. This test ran for a total of 202 days from April to November, 1937. Rainfall during the period totaled 24.23 inches, which averaged slightly higher than for the first experiment, reported last year.

The steers used in this experiment were of more uniform quality than those in the first test. They were divided into groups with initial average weights ranging from 625 to 650 pounds, and placed on the following pastures:

Group I—Pigeonpea pasture, comprising a good stand of this legume with undergrowth and forage around the edges consisting of Spanish clover, Spanish needle, honohono (*Commelina diffusa*), Dallas grass (*Paspalum dilatatum*), Natal redtop (*Tricholaena repens*), and kikuyu (*Pennisetum clandestinum*).

Group II—Planted-grass pasture, originally of Rhodes grass (*Chloris gayana*) and kikuyu, and also containing Bermuda (*Cynodon dactylon*), Hilo grass (*Paspalum conjugatum*), pilipiliula (*Andropogon aciculatus*), Spanish clover, and weeds.

Group III—Rough pasture on pahoehoe lava, having an abundance of weeds on the thin spots but with hollows containing nice growths of Bermuda, Natal redtop, and other grasses.

Results of this experiment are summarized in table 18.

Based on the value of the increased beef resulting through molasses feeding, this byproduct, as an average of 2 years, had a gross value of $12.72 per ton when supplementing pigeonpea pastures. With grass pastures the average for the 2 years gave molasses a value of $8.61 a ton.

TABLE 18.—Results of second beef-fattening experiment at Kapapala Ranch (202 days)

Pasturage	Group I Pigeon-pea		Group II Planted grasses			Group III Rough pasturage
Lot	A	B	A	B	C	A
Acreage	21	21	17	17	17	Approximately 80
Number of steers	15	15	9	9	9	12
Supplements fed per pound of gain:						
Molasses (pounds)	....	2.61	....	5.43	4.41	3.89
Soybean-oil meal (pounds)	....	....	....	....	2.42	....
Fish meal (pounds)	....	....	....	....	....	0.62
Average final weight (pounds)	977	1,038	942	957	972	992
Average initial weight (pounds)	635	623	634	648	632	633
Average gain in weight (pounds)	342	415	308	305	340	359
Mean daily gain in weight (pounds)	1.69	2.05	1.52	1.53	1.68	1.77
Standard deviation of the means (pounds)	0.32	0.26	0.24	0.13	0.20	0.25
Ratio of dressed weight to live weight (percent)	56.2	56.5	52.5	55.3	56.8	52.9
Average price received per pound dressed weight (cents)	18.40	18.45	18.10	18.25	18.38	18.38

Carcass studies showed that the molasses-fed animals were one-third of a grade higher than the no-molasses lots in both pigeonpea and grass pastures. The meat was more highly marbled when the supplement was fed. The practical application of the feeding of this byproduct is further shown by the higher carcass values of the molasses-fed steers.

Protein supplements in addition to the molasses in both years produced only slightly greater gains, insufficient to pay for the cost of such supplements. (Henke, Work, Burt)

Commercial Beef Fattening

Many ranches in the Territory are limited in beef-carrying capacity by the lack of rainfall and grass during certain seasons. Several ranchers are now increasing the productive capacity of their pasture lands by bringing the weanlings to some central point and fattening them with cheap local feeds, chiefly molasses and pineapple bran. This practice utilizes the existing grass for breeding stock and thus adds to the calf crop of the ranch. Desirable steers of 800 to 1,000 pounds live weight are being finished off under these conditions in a 6-month feeding period. In one such feeding pen, where rather accurate records have been kept, weanling calves gained at the rate of 1.8 pounds per day on a ration, originally devised by this station, consisting of 40 parts molasses, 40 parts dry pineapple bran, and 20 parts protein supplement, plus a small amount of green feed. (Henke, Work)

Digestibility of Hawaiian Feeding Stuffs

A study of the value of local feeding stuffs from the standpoint of digestion coefficients has been continued, mainly on forage crops. Because Napier grass (*Pennisetum purpureum*) seemed to have too high values as reported last year, a second trial was conducted. The values obtained in the second trial were lower than in the first.

Table 19 gives a summary of the data obtained in this work during the past year. All coefficients were obtained as results of two consecutive 10-day collection periods following a minimum 10-day preliminary period. The values obtained for fish meal and for pineapple bran were obtained indirectly.

Our tests of pineapple bran, conducted in such a manner as to duplicate the work at California except for the animals used, resulted in a higher coefficient for the protein and a lower coefficient for the fat. The total nutrients are about the same. Exact agreement between Hawaii and California figures cannot be expected. (Work)

TABLE 19. — Analyses, digestion coefficients, and digestible nutrients of additional Hawaiian feeding stuffs (as fed)

Feed studied	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber	Ash	Total nutrients
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Green Napier grass[1] (*Pennisetum purpureum*) full growth, young							
Composition	23.80	1.23	9.60	0.47	9.41	3.08	
Digestion coefficients		53.00	63.00	64.00	71.00		
Digestible nutrients		.65	6.05	.30	6.68		14.06
Green sugarcane tops							
Composition	22.75	1.37	10.54	.47	8.49	1.88	
Digestion coefficients		54.00	54.00	53.00	60.00		
Digestible nutrients		.74	5.70	.56	5.09		12.79
Hawaiian tuna-fish meal							
Composition	90.13	58.30	3.41	7.36	.71	19.89	
Digestion coefficients		76.00	....	97.00	....		
Digestible nutrients		44.31	....	7.14	....		60.37
Green honohono (*Commelina diffusa*)							
Composition	12.13	1.32	5.57	.26	3.28	1.69	
Digestion coefficients		65.00	79.00	54.00	64.00		
Digestible nutrients		.86	4.41	.15	2.10		7.71
Dried pineapple bran (without molasses)							
Composition	86.46	3.79	58.49	1.74	19.86	2.59	
Digestion coefficients		15.00	79.00	53.00	79.00		
Digestible nutrients		.57	46.21	.92	15.90		64.54
Desmanthus virgatus—all of green stem with leaves and some seed pods							
Composition	38.34	4.40	15.70	.93	15.07	2.24	
Digestion coefficients		44.00	59.00	47.00	44.00		
Digestible nutrients		1.94	9.26	.44	6.63		18.82

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[1] Digestion coefficients on Napier grass are the average of two different trials.

SWINE

Pineapple-Bran Ration

Continuing the work previously reported, a second lot of pigs was fed the pineapple-bran ration consisting of: Pineapple bran, 61.6 pounds; cane molasses, 12.4 pounds; fish meal, 12.4 pounds; soybean-oil cake meal, 12.4 pounds; bone meal, 0.6 pound; and salt, 0.6 pound.

Seven Tamworth × Berkshire pigs averaging 120 pounds initial weight were self-fed for 43 days to a final market weight of 190 pounds. These pigs consumed 8.19 pounds of concentrate daily to make an average gain of 1.63 pounds per day, or a pound of gain on 5.22 pounds of feed at a cost of 5.2 cents, as compared to pigs on a control ration, largely composed of mainland feeds, that made an average gain of 1.60 pounds per day (4.80 pounds feed per pound gain) at a feed cost per pound gain of 9.6 cents.

The feed utilization in this test is similar to that reported last year. The average daily gain is much greater than when lighter pigs were fed the same ration. These results bear out earlier work at this station and show that finely ground dried pineapple bran is an economical feed for fattening swine of 100 pounds or more initial weight. (Work, Henke)

Roasted Soybeans as Protein Supplement in Swine Rations

Eleven crossbred pigs averaging 94 pounds initial weight were placed on a feeding test to determine the value of ground roasted soybeans and soybean-oil meal as compared to Hawaiian tuna-fish meal. The trial was continued for 57 days, with four pigs receiving the roasted soybean ration, three the soybean-oil meal, and four the fish-meal or check ration.

Because of the small number of animals on test, the results are somewhat unreliable. The concentrates consumed per pound of gain were 4.2 pounds of the roasted soybean ration as compared with 4.7 pounds of soybean-oil meal and 4.6 pounds of the check ration. This work is being repeated. (Henke, Work)

Litter Records of Sows on University Farm

The litter records of the sows on University farm are now available over a 20-year period. Table 20 summarizes these data.

The records cover 168.6 sow-years, during which period 255 litters were farrowed with a total of 1,968 pigs, 1,170 of which were raised to 2 weeks of age. All but about 5 percent of losses up to weaning in this herd have occurred within that time.

TABLE 20. — Litter records of sows on University farm by 10-year periods (1918-1938)

Breed	Fiscal years	Total sow-years (sows 1 year old and over)	Total pigs born including dead pigs	Number of litters aborted	Average litters per sow per year	Average pigs per litter	Pigs per sow-year raised to 2 weeks of age
Berkshire	First 10 years (1918-28)	40.2	429	2	1.37	7.8	6.6
Do	Second 10 years 1928-38)	39.2	479	1	1.61	7.6	6.3
Do	Total 20-year period	79.4	908	3	1.49	7.7	6.4
Tamworth	First 10 years (1918-28)	20.9	227	0	1.44	7.6	6.3
Do	Second 10 years (1928-38)	64.4	787	0	1.57	7.8	7.6
Do	Total 20-year period	85.3	1,014	0	1.54	7.7	7.2
Crossbred Berkshire × Tamworth	2-year period (1936-38)	3.9	46	0	1.54	7.7	10.3
All sows	First 10 years (1918-28)	61.1	656	2	1.39	7.7	6.5
Do	Second 10 years (1928-38)	107.5	1,312	1	1.58	7.7	7.2
Do	Total 20-year period	168.6	1,968	3	1.51	7.7	6.9

Over the entire 20 years the Tamworth unit, as a whole, has been somewhat more productive than the Berkshire. Although the litters per year and pigs born per sow were not greatly different, the main reason for the apparent superiority of the Tamworths was a lower mortality rate (only 38.9 percent as compared to 43.8 percent for the Berkshires).

Of the 1,905 pigs born whose sex was recorded, 52.2 percent were male and 47.8 percent female (see table 21). (Henke, Work)

TABLE 21.—Sex ratio of pigs born in University herd over 20-year period (1918-1938)

Breed	Number of pigs born		Ratio of pigs born	
	Males	Females	Males	Females
			Percent	*Percent*
Berkshire	459	423	52.0	48.0
Tamworth	514	463	52.6	47.4
Crossbred Berkshire × Tamworth	21	25	45.7	54.3
Total	994	911	52.2	47.8

TRIALS OF NONPROTEIN NITROGEN RATIONS

A preliminary trial of urea as a protein supplement in swine rations was conducted, with four pigs on a check and two on a urea-supplement ration. The urea-fed pigs did not develop uniformly, one gaining as much as the checks but the other, considerably less. The results are not conclusive but indicate that perhaps urea may be used to supplement protein in the ration. This trial is being repeated with a reduction in the barley content of the ration.

Just before the close of the year, two calves were placed on a ration with urea as the major constituent, two on a check ration, and one on a low-protein ration from which the two former rations were built up. These calves will be fed their respective rations until the beginning of lactation, at which time compensation will be made for the milk protein and the rations continued. (Work)

PARASITOLOGY

Liver Fluke (*Fasciola gigantica*) of Cattle

Longevity of Liver-fluke Cysts

Experiments were conducted to determine the longevity of encysted metacercariae attached to vegetation. Leaves of honohono (*Commelina diffusa*) experimentally infected with fluke cysts, were replanted outdoors either on the ground in sunny or shady areas, or in a layer of soil at the bottom of a water trough submerged in running water. Additional infected leaves were allowed to dry indoors to study the resistance of the cysts to desiccation. After various intervals, the cysts were fed to guinea pigs to determine their viability.

These experiments indicated that fluke cysts subjected to desiccation indoors were viable after 20 days but not after 30 days; cysts attached to whole plants and kept in sunny areas were viable after 15 days but not after 42 days; cysts attached to plants or detached leaves and kept in running water were viable after 4 months but not after 8 months. After the last-mentioned interval, although the cysts appeared in fair condition, the leaves to which they were attached had decayed, a factor which may account for the death of the cysts. (Alicata)

Development of Liver Fluke in the Final Host

Observations were made on the development of this parasite in a calf, 5 rabbits, 1 pig, and 5 guinea pigs, all of which had been fed infective fluke cysts. The guinea pigs were killed at intervals from 9 to 40 days after infection, and were found to harbor immature flukes ranging from 0.73 to 8 mm in length and from 0.35 to 3 mm in width. The pig, killed 64 days after infection, contained in the liver immature flukes 20 to 28 mm long by 4 to 6 mm wide.

In order to determine when fluke eggs were first eliminated, the feces of the rabbits and the calf were examined, beginning with the fiftieth day following experimental infection, and twice weekly thereafter. Fluke eggs were found in the feces of four rabbits 77 days after infection; with one rabbit and the calf, eggs were found 84 days after infection. The rabbits, which were killed a few days after the appearance of the eggs in the feces, harbored adult flukes ranging from 26 to 32 mm long and from 6 to 10 mm wide. The calf, killed 216 days after infection, showed adult flukes in the liver 37 to 42 mm long by 11 mm wide. (Alicata)

Life Cycle of the Intermediate Snail Host, Fossaria ollula

The life cycle of *Fossaria ollula,* including the period and frequency of oviposition and the span of life, was studied, for the most part under laboratory conditions. From observations on 13 laboratory-raised snails it was found that oviposition began from 26 to 42 days following hatching, at which time the snails had attained a size of about 9 to 9.5 mm long by 4.5 to 5 mm wide. The life span of 5 snails varied from 114 to 164 days, and the total number of eggs deposited by each snail varied from 677 to 2,384. The individual gelatinous masses enclosing the eggs deposited by a snail ranged from about 1 to 21 mm in length and from 1 to 3.5 mm in width, and contained from 1 to 92 eggs. Under natural conditions the eggs developed and hatched within from 6 to 10 days.

The data obtained did not indicate that the number of gelatinous masses or number of eggs deposited by each snail showed any particular correlation with either the age of the snail or with the month (February to June) during which observations were made. Since the snails in the experiments survived less than one-half year, it is not possible to determine whether oviposition was influenced by seasons. Under natural conditions, eggs of this snail have been observed in streams and marshes on Oahu every month, indicating that oviposition goes on throughout the year. It is possible that, since the temperature from one season to another shows little variation in Hawaii, the rate of oviposition is about the same throughout the year. (Alicata)

Longevity of Liver Fluke in Cattle

On January 2, 1937 an experiment was begun, with the cooperation of a ranch on Molokai and the Board of Agriculture and Forestry, to determine the longevity of liver fluke in cattle. Five calves at weaning age were fed about 800 fluke cysts each and subsequently were kept in a dry, nonfluky area. On the following March 23, the feces of these animals were examined and found negative for fluke eggs. Reexaminations made on May 7 and August 3, 1937, and on February 18, 1938, showed all animals passing fluke eggs. On May 25, four animals were passing fewer eggs in the feces than previously, and one animal was found negative. About a month later (June 23) the negative animal was killed. At necropsy the surface of the liver was mottled, and the inside showed considerable fibrosis; the larger bile ducts were thickened and hard, and the lining was rough. No flukes were found in the ducts. One dead and badly decomposed small fluge was found encysted in the liver tissue. Two immature flukes, about 20 to 25 mm long by 5 to 6 mm wide, were found partially encysted; when placed in physiological saline solution, one of these flukes remained immotile while the other showed slight movement.

The results thus far obtained indicate that liver flukes are able to live at least 17 months; however, some die earlier as evidenced by the reduction of egg output in the feces and failure to find adult flukes in the liver of the animal slaughtered. (Alicata)

Effects of Liver Flukes on Milk Production and Body Weight of Dairy Cows

Five pregnant cows at the University farm were fed encysted metacercariae ranging in number from 5,000 to 20,000. One cow lost 200 pounds in 4 months, and her average daily milk production decreased from 35 pounds the second week after calving to 21 pounds at the end of the fourteenth week. In the following week, the milk production was 8.5 pounds, a decrease of 60 percent from the previous week. During the following 3 weeks, production was irregular, and, because of her condition, milking was discontinued. The other four cows maintained their milk production and body weight.

Prenatal Infection of Calves with Liver Flukes

In connection with the above study, calves from three of the experimentally infected cows were found to be infected when they were from 59 to 96 days of age. The other two calves and three control calves were not infected. (Goo, Henke, Work)

Treatment of Fluke-infected Cattle with Distol

The experimental treatment of fluke-infected cattle with Distol was continued during the year.

Of six animals which had been raised in the same fluke-infected swamp, three were treated with Distol and slaughtered about 2 months later. The three control cattle, not treated with Distol, were slaughtered at the same time. Post-mortem examinations showed that the control animals were heavily infected (75 to 350 live flukes per liver). The three animals treated with Distol showed 0, 1, and 4 flukes in their livers.

Fifty-four nonlactating cattle, ranging in weight from 150 to 1,300 pounds, were treated with varying dosages of Distol without any deleterious effects. Microscopic examinations of the excrement of cattle for fluke ova before and after treatment indicate that Distol was very effective in destroying the flukes. Comparison of cattle before and after treatment showed marked improvements in flesh conditions.

Twelve pregnant cows, one of which had aborted the previous year, were treated with Distol from 6 to 56 days before parturition. All calved normally, and there was no indication that milk flow was impaired by the drug. (Goo, Alicata)

Treatment of Fluke-infested Cattle with Kamala

Kamala is derived from the glands and hairs of the capsule of *Mallotus philippinensis,* a small tree indigenous to India, China, and the Philippines. The active principle is rottlerin. This drug has been reported effective in destroying flukes in sheep but, when given to cattle in amounts sufficient to kill the flukes, sometimes caused exhaustive or fatal diarrhea. Since the drug is less expensive than Distol and obtainable in the United States, a series of experiments was conducted.

Four fluke-infected animals varying in weight from 465 to 1,020 pounds were treated with dosages of powdered kamala at the rate of 1 gram to 5 pounds live weight, divided and administered over 3 or 4 days. On post-mortem examination no live flukes were found in any of the livers.

A group of 10 infected nonlactating cattle varying in weight from approximately 175 to 1,150 pounds were treated with kamala at the rate of 1 gram per 5 to 9 pounds live weight. The cows suffered from diarrhea during and for a few days after the treatment. A comparison before treatment and 3½ months after treatment showed that these cattle had improved markedly in flesh and condition. Microscopic examinations of the excrement of each animal after treatment indicated that the flukes were entirely eliminated in 9 of the 10 cattle treated.

Three pregnant cows, weighing 1,170 pounds, were each treated with 160 grams of kamala, divided in daily doses of 40 grams. The three cows calved 18, 21, and 9 days after treatment, and their milk production records were somewhat higher than for their preceding lactation. (Goo, Alicata)

Treatment with Extract of Male Fern (Oleoresin of Aspidium)

A 450-pound heifer was treated with 60 cc of extract of male fern, divided into 3 daily doses of 20 cc each. Microscopic examinations of the excrement before and after treatment indicated no reduction in infection. A dosage of 120 cc of the extract given in 2 days to an 850-pound cow proved fatal. (Goo)

PARASITES OF SWINE

Prevalence of Swine Parasites

A study has been made to determine the prevalence of swine parasites on the islands of Oahu and Kauai. The following cases of parasitism were found in 103 swine examined on Oahu: *Ascaris suum*, 21 cases; *Oesophagostomum dentatum* (nodular worm), 32 cases; *Strongyloides* sp., 43 cases; *Trichuris suum*, 7 cases; *Balantidium coli*, 3 cases; coccidia, 46 cases.

An examination of swine on the island of Kauai revealed the common presence of roundworms (*Ascaris suum, Oesophagostomum dentatum, Strongyloides* sp.) and coccidia.

Strongyloides, Balantidium, and coccidia were noted most commonly in young pigs. Considerable dysentery and ulceration of the lining of the large intestine were noted in balantidial infestations. (Alicata)

POULTRY PARASITES

Relation of Nutrition to Ascarid Infection

Nutrition is known to play an important part in the control of certain poultry parasites. Studies were conducted to determine the value of supplementing a poultry ration with animal or vegetable protein concentrates. The basal ration consisted of:

	Parts
Corn meal	40
Rice bran	12
Wheat bran	17
Wheat middling	18
Bone meal	2
Oyster shell	3
Alfalfa meal	5
Cod-liver oil	2½
Table salt	½

Supplements fed were:

	Parts
Group 1	
Dried skim milk	20
Group 2	
Sardine meal	13
Group 3	
Soybean meal	14
Sesame meal	11
Group 4	
Sardine meal	14
Dried skim milk	4

All birds were placed on their respective diets from the time of hatching. At the age of 5 weeks, each bird was fed about 1,000 embryonated eggs of *Ascaridia galli*. About 6 weeks later, allowing sufficient time for the parasites to reach maturity, all the birds were killed. The average numbers of parasites found in the small intestines of the chickens at autopsy are shown in the table below:

TABLE 22.—*Ascaridia galli* infection in poultry fed supplemental vegetable or animal protein concentrates

Group	Number of birds	Supplement	Digestible protein	Total digestible nutrients	Average number of parasites found	
					Adult[2]	Immature[3]
			Percent	*Percent*		
1[1]	50	Dried skim milk	13.8	67.1	0.5	11.5
2[1]	55	Sardine meal	14.7	65.1	.5	7.9
3	35	Soybean and sesame meal	15.3	67.0	12.7	3.8
4	35	Sardine meal and dried skim milk	15.7	65.8	2.1	2.1
5[1]	55	None (check)	9.9	63.8	44.2	3.4

[1] The data represent summarized results of two trials.
[2] Parasites 30 mm or more in length.
[3] Parasites less than 30 mm long (a large number were between 5 and 15 mm long).

The table shows that birds on a diet containing animal protein concentrates (groups 1, 2, and 4) developed fewer parasites than those receiving vegetable protein concentrates (group 3). In addition, group 3 developed fewer parasites than the check group. Figures 9 and 10 illustrate the importance of an improved diet in reducing parasitism and maintaining the health of poultry.

Life History of the Tapeworm, Hymenolepis exigua

Experiments have been conducted to determine the complete life cycle of *Hymenolepis exigua*, a common tapeworm of poultry. The eggs of this parasite, ingested by sandhoppers (*Orchestia platensis*), developed to the cysticercoid stage infective to chickens in about 12 days. Cysticercoids fed to chicks developed to mature tapeworms in 9 or 10 days.

In order to determine other possible intermediate hosts, sow-bugs (*Porcellio laevis*), beetles (*Tenebroides nana*), and undetermined species of earthworms were exposed to infection with eggs of *H. exigua* but remained negative. The examinations of house flies, roaches (*Pycnoscelus surinamensis*), earwigs (*Euborellia annulipes*), and sow-bugs from known-infested poultry yards, were also negative for larvae of *H. exigua.* (Alicata, Chang)

Intermediate Hosts of the Caecal Fluke, Postharmostomum gallinum

Laboratory studies have determined that two land snails, *Eulota similaris* and *Subulina octona*, serve as carriers of the caecal fluke of poultry under natural conditions in Hawaii. Snails collected in fluke-endemic

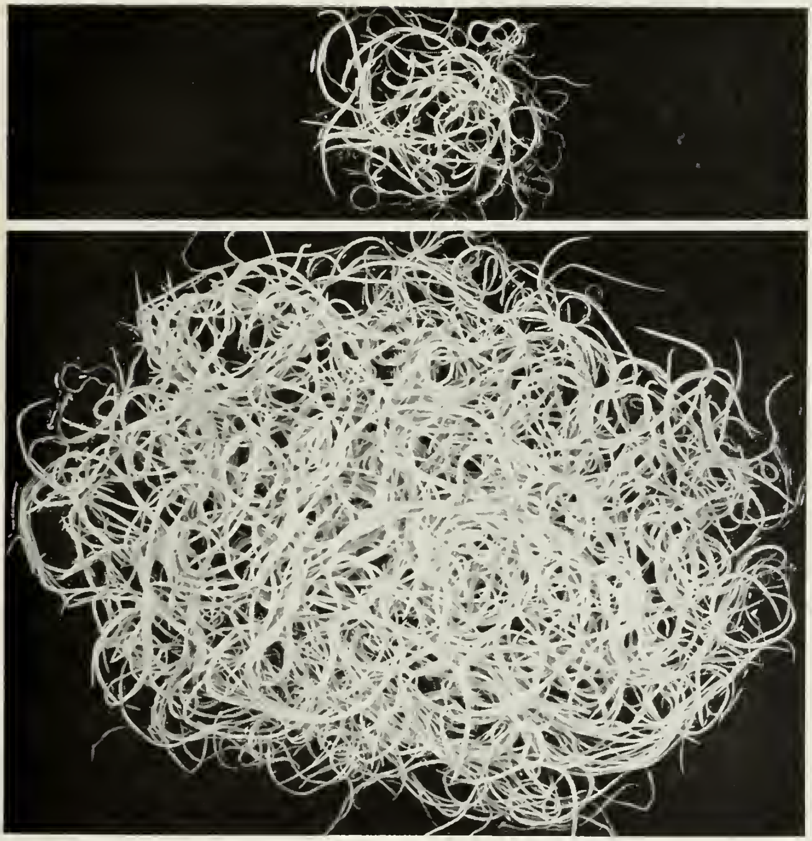

FIGURE 9.—(*Upper*) *Ascaridia galli* recovered from 25 birds on basal ration, receiving no protein supplements; (*lower*) *Ascaridia galli* recovered from 25 birds in group 2, receiving a supplement of sardine meal (see p. 80)

poultry farms near Honolulu have been found heavily infected with larval flukes (adolescariae). Chicks have become infected as a result of being fed larval flukes obtained from the snail, *E. similaris.* The larvae reached maturity in birds about 1 month after experimental infection. The larvae found in *S. octona* have been determined, on the basis of morphology, to be those of *P. gallinum.* (Alicata)

Additional Intermediate Hosts for the Gizzard-worm, Cheilospirura hamulosa

Additional studies to determine arthropods that may transmit gizzard-worm to chickens have revealed that the beetles *Dermestes vulpinus* and

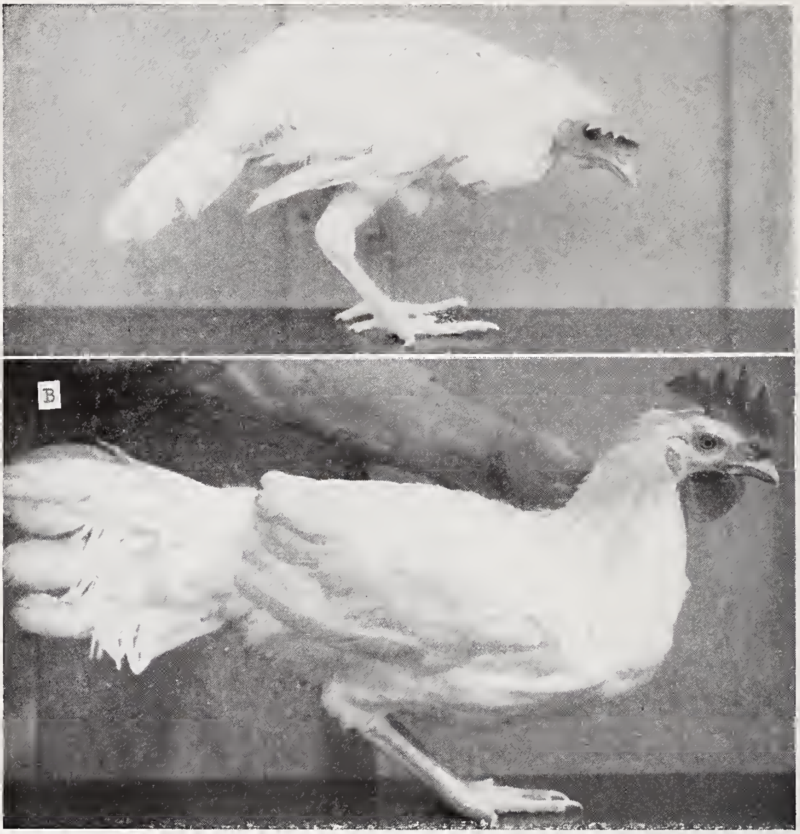

FIGURE 10.— (*Upper*) One of the birds, 12 weeks old, fed basal ration; (*lower*) one of the birds in group 2 receiving sardine-meal supplement (see p. 80)

Gonocephalus seriatum collected from poultry yards were naturally infected with gizzard-worm larvae. Fifteen other intermediate hosts were reported in the annual report of this station for 1937. (Alicata)

Parasites of Pigeons in Hawaii

Ornithostrongylus quadriradiatus, an intestinal roundworm of pigeons common in many parts of the world, has been found prevalent in local pigeons and is believed to be responsible for considerable unthriftiness and death.

Pigeon-malaria, due to *Haemoproteus columbae,* has also been found to be of common occurrence. The pigeon-fly, *Pseudolynchia maura,* the known vector of this parasite, also infests local birds. (Alicata)

POULTRY HUSBANDRY

Poultry Rations

Cane Molasses in Laying Rations

In continuation of an investigation to determine the value of cane molasses in laying rations, four lots of Single Comb White Leghorns were fed rations containing 0, 3, 5, and 7 percent cane molasses. These trials were conducted as a check to those reported last year. Data presented in 1937 indicated that the 3-percent-molasses group had the highest egg production per hen, the highest wholesale value of eggs, and the best returns above feed cost per hen.

Results similar to those of last year were obtained in the more recent experiments.

Algaroba-Bean Meal in Laying Rations

A preliminary trial, in which 1 lot of 22 Single Comb White Leghorn pullets and 1 lot of 100 Single Comb White Leghorn hens were fed a ration that contained 20 percent algaroba-bean meal, was initiated January 1 and terminated May 31, 1938. Data obtained over the 5-month period show that the mortality was 13.64 percent in the pullet lot and 4 percent in the hen lot. An average egg production of 76 for the pullets and 66 for the hens gave a return above feed costs of $2 for each pullet and $1.44 for each hen.

All-Hawaiian Emergency Laying Ration

During the maritime strike a shortage of prepared commercial feeds in the Territory led to the development of an emergency maintenance ration, in which local feedstuffs only were used. This ration was composed of pineapple bran, algaroba-bean meal, yellow corn, coral sand, and salt, supplemented with crushed coral rock, koa haole leaves, and a wet mash composed of the above ingredients. Forty-eight pullets were fed the emergency ration for 3 months. All birds lost weight and nine pullets died during the trial. For a subsequent period of 3 months, 37 of these pullets were fed a regular laying ration to determine whether chickens could be restored to normal physical condition after such an emergency period. The 11 Single Comb White Leghorns gained an average of 0.5 pound and the 26 Barred Plymouth Rocks 1.18 pounds per bird. Both groups came into egg production within a period of 3 weeks. The

Leghorns averaged 24.82 eggs per bird and the Barred Plymouth Rocks, 50.54. Returns above feed costs for the period of 32 cents for the Leghorns and 82 cents for the Barred Plymouth Rocks indicated that the all-Hawaiian ration was not permanently detrimental to the physical condition of the birds. (Bice)

OTHER STUDIES

Breeding for High Egg Production and Resistance to Diseases

The objective in this project is to develop families resistant to diseases such as pullorum, neurolymphomatosis, and coccidiosis, and to maintain high egg production. Twenty-six hens in one family or line have laid more than 300 eggs per hen, the highest record being 329 eggs in 365 consecutive days.

All-steel or Semi-steel Poultry Houses

A detailed description of the all-steel and semi-steel poultry houses was given in the 1937 annual report. Recordings were obtained during the past year to determine the temperature conditions of the all-steel and semi-steel poultry houses as compared with houses constructed of wood. Thermometers were placed in the centers of the houses, and temperature recordings were made six times daily between the hours of 7 a.m. and 4 p.m. The average temperatures recorded over 1 month indicate that the steel and semi-steel houses are no hotter than outside temperature and are cooler than the wooden house by only 1° to 2° F. (Bice)

FOODS AND NUTRITION

Nutritive Value of Foods

Biological Determination of Vitamin Values

Although the vitamin C (ascorbic acid) content of foods can be determined by chemical means, and spectroscopic methods are satisfactory for some of the vitamins in certain types of material, biological experiments continue to be the most valuable method of determining the relative quantities of the different vitamins in natural foods.

The results of animal-feeding tests are made more nearly quantitative by the establishment of curves of response for each laboratory making vitamin determinations. Pure forms of several of the vitamins are now available. By feeding graded doses of these pure substances to groups of animals, curves of reference may be established with which to compare the growth response of animals fed varying quantities of natural foods.

How young rats respond to increasing quantities of vitamin B is well shown in figure 11. At 3 weeks of age, 192 healthy rats were placed on a diet complete in every respect except as to vitamin B. About 3 weeks later, when the vitamin B reserves of the body had become depleted, the animals were assigned to feeding groups. One or more rats from each litter constituted the group continued on the basal diet until they succumbed. The rats in the other groups were fed a solution of vitamin B by calibrated pipettes. Figure 11 shows the results of feeding varying quantities (from 1 to 16 micrograms daily) of synthetic vitamin B hydrochloride for a period of 5 weeks. The gains in weight show a curvilinear relationship to the doses given and, when plotted against the logarithms of the doses, fall in almost a straight line. Establishing such curves of response for the different vitamins for comparative purposes simplifies and increases the accuracy of the determination of the vitamin values of natural foods by the biological method. (Miller)

Nutritive Value of the Opihi

Experiments in progress for some years to determine the nutritive value of the opihi, or Hawaiian limpet—favorite shellfish of the Hawaiians—were concluded. Early results were summarized in the 1936 experiment station report. This shellfish is an excellent source of vitamin

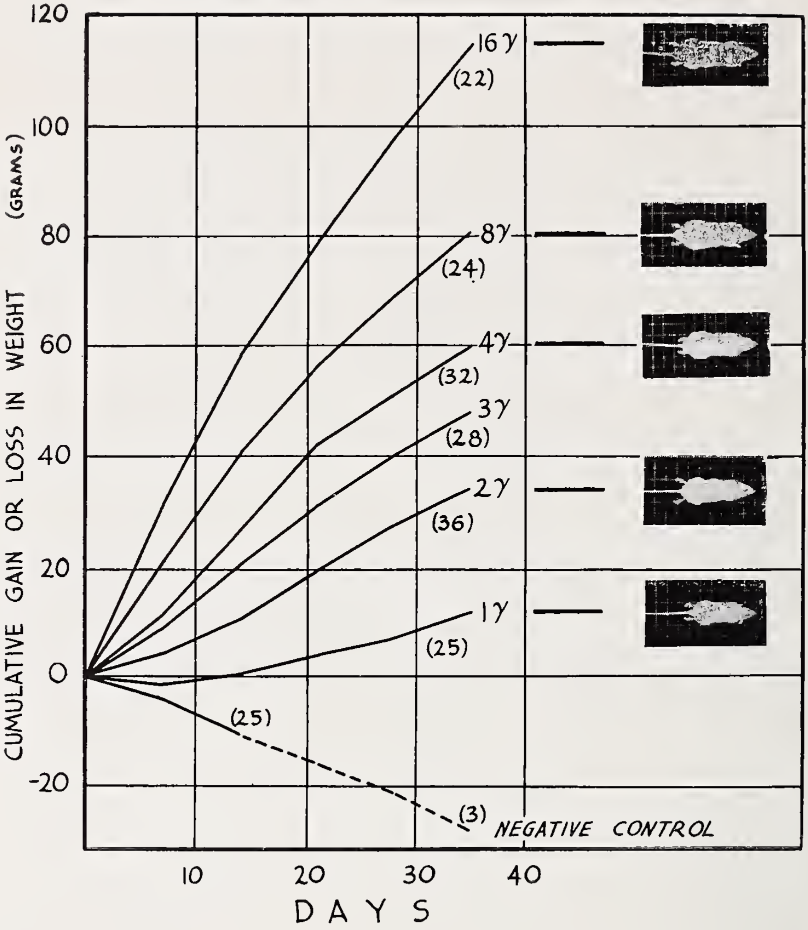

FIGURE 11. — Average growth response of groups of rats fed varying quantities of synthetic crystalline vitamin B_1 (thiamin) after depletion of vitamin B stores. (The figures in parentheses show the number of rats used for each test. The broken line indicates the occurrence of the first death in the control group.)

A. Whole fresh opihi contain, per 100 grams, 4,000 international units of vitamin A, 130 Sherman-Bourquin units of vitamin G (about 300 γ flavin), and 30 international units of vitamin D. They contain little or no vitamin B and are devoid of vitamin C. (Miller)

Taro as a Dietary Source of Calcium

The availability of the calcium and phosphorus of taro to the human body was determined by means of balance studies on two adult women. In the mixed, adequate diet used, over three-fourths of the calcium and almost half the calories and phosphorus were supplied by taro. In comparing results with similar studies on other foods, it was concluded that the calcium of taro is as well utilized by adult women as is that of plant foods in general. Both subjects were in positive phosphorus balance throughout the experiment, but the intake of this mineral was too high to permit of an evaluation of the availability of the phosphorus of taro.

Experiments with young rats also showed that the calcium of taro was well utilized. The calcium retention of rats fed a diet in which taro furnished 97 percent of the calcium and 58 percent of the phosphorus of the diet was compared with the calcium retention of litter-mate rats fed a diet in which starch and soluble inorganic calcium and phosphorus salts replaced the taro. The calcium and phosphorus of these inorganic salts have been proved by a number of laboratories to be extremely well utilized. Experiments conducted in the station laboratory showed that the calcium of taro is nine-tenths as well utilized by the young rat as is that of calcium monophosphate $[Ca(H_2PO_4)_2H_2O]$. (Potgieter)

DIETS OF RACIAL GROUPS

Chemical Analyses of Filipino Foods

The work of analyzing Filipino foods reported in 1937 was continued, 13 different foods having been analyzed to date. It is planned to include the results of these analyses in a station bulletin together with data on the nutritive value and use of these foods in Hawaii. (Miller, Louis)

Studies in Family Living

Observation and recent unpublished studies of the food intake of various groups in the Territory show that the diets of many of the people here are probably deficient in at least two or three dietary constituents essential for optimum growth, resistance to infections, and good dentition. A detailed analysis of the types of diets of various racial groups would yield valuable information for use in nutrition teaching, for the groups as a whole and for the individual families studied.

A preliminary group, composed of 12 independent Japanese vegetable growers and their families, living about 15 miles from Honolulu, was studied during the past year. This group is representative (as to race, length of residence in Hawaii, and occupation) of a rather large percentage of the total population of the Territory. Four of the twelve families own part or all of the land they operate. The number of acres farmed ranged from 1 to 8, with an average of 3.2.

The diets of these 12 families were found, on the average, to be deficient in calcium and in vitamins A and B; just adequate in calories, phosphorus, iron, and vitamin C; and above standard in protein. The diets as a whole of these 12 families are inadequate, and the nutritional status of the children (both by clinical examination and by body weight and measurements) were definitely, though not seriously, below par. Ninety-seven percent of the 39 children examined in these families had dental caries; the families with nearly adequate intakes of calcium tended to have fewer carious teeth per child than did the families with more inadequate intakes of this mineral.

The average total value of family living in this group was $1,984 per year, with an average yearly expenditure per person of $310. The largest item in the family budget was for food, averaging over 40 percent (26 to 52 percent) of the total expenditures in the 12 families. The value of family food produced at home per month averaged $7.48, ranging from $1.34 to $17. This consisted chiefly of vegetables, but included also some fruits, eggs, chickens, and, in one family, milk and butter. The average cost of food per person per year was $131. All the diets of these 12 families were below standard in one or more of the 8 dietary essentials studied. However, it was seen to be true here, as elsewhere, that the amount of money spent for food is not always an indication of the adequacy of a family's diet. The diet of the family having the highest rating as to nutritional adequacy cost less per person per year than did the diets of three of the other families. (Potgieter, Takase, Louis)

ANEMIA STUDIES

Influence of Splenectomy on Recovery from Nutritional Anemia in Rats

In studies previously reported it was found that the spleen of an anemic rat enlarged during the period of recovery and returned to normal size as the blood condition of the animal reached normal levels. The enlargement of the spleen was due to the appearance of actively erythropoietic tissue, the later decrease in size of the organ being caused by the disappearance of this tissue.

Studies of the influence of the spleen on recovery of rats from nutritional anemia were completed during the past year. Thirty-five animals were weaned at 21 days of age and fed an exclusive diet of milk. The animals developed severe anemia in 5 to 7 weeks. Four of these animals were killed as controls, sixteen were subjected to splenectomy after they had become anemic, and 15 were subjected to laparotomy only, to serve as a control for the study of the influence of the spleen on recovery. All splenectomized animals and animals subjected to laparotomy were fed 0.5 milligram of iron and 0.25 milligram of copper daily as supplements to the milk diet, these quantities of the supplements being known to induce rapid recovery from anemia. Daily determinations of hemoglobin levels, numbers of erythrocytes and leucocytes, and differential counts of the leucocytes were made on all the animals in an effort to discover differences in the rate and nature of the recovery of the two groups of animals. The following conclusions were drawn:

1. The presence of the spleen apparently is not necessary for growth or for normal regeneration of hemoglobin and erythrocytes.

2. Definite periods of increase in the number of nucleated cells of all anemic rats that have been fed copper and iron as a curative substance occur on the second day and on the fifth or sixth day.

3. The increase in number of nucleated cells on the second and fifth or sixth day of recovery is greater for splenectomized animals than for non-splenectomized animals.

4. The greater increase in the numbers of nucleated cells in the splenectomized animals indicates that removal of the spleen disrupts the physiological equilibrium of the haematopoietic system.

5. A new haematopoietic equilibrium for the splenectomized animals appears to be established after about 8 days of recovery, for abnormal blood cells have disappeared from the blood of the animals at that time and do not recur.

Postnatal Changes of the Blood and of the Blood-forming Organs

Since the condition of the rat at birth is relatively immature and the rats used in the anemia studies were but 28 days of age when placed on experiment, a study of the postnatal changes of the blood and the blood-forming organs was undertaken to determine what bearing postnatal changes might have on the experiments. Eighty-seven animals from the breeding colony on an adequate diet were killed at various intervals from the time of birth to 100 days of age. Members of a second lot of 48 animals, from the group used for anemia experiments, were killed at intervals from the time of birth up to 80 days of age. The results of the studies were as follows:

1. Animals fed adequate diets and milk diets grew at the same rate up to the time of weaning, when those receiving milk began to show a decrease in the rate of growth. At 67 days of age, animals receiving milk weighed an average of only 74 grams while those that received the breeding diet weighed 199 grams.

2. The hemoglobin level of young rats at birth was found to be between 10 and 11 grams per 100 cubic centimeters of blood. It decreased during the first few days after birth and reached its lowest level of 8 grams for animals receiving a breeding diet, but increased to 14.5 grams by the sixty-seventh day. Animals receiving milk showed a similar hemoglobin level at 7 days of age but the hemoglobin level continued to decrease beyond that point, reaching 2.4 grams at 67 days of age.

3. The erythrocytes per cubic millimeter of blood numbered about 2.5 million at birth. The number increased gradually in animals receiving a breeding diet and reached 7.7 million at 67 days of age. The red blood cells of animals receiving a milk diet also increased after birth but reached their greatest number of 4.8 million at 28 days of age. A decrease then followed and the number at 67 days of age was about 2 million.

4. The number of platelets at birth was about 250,000 per cubic millimeter of blood. They increased in number with increase in age, reaching a maximum of 600,000. Differences in the number of platelets could not be demonstrated for the two groups.

5. The number of leucocytes of the circulating blood was very irregular. The number for the milk-fed animals decreased during the last portion of the experiment to 5,000 per cubic millimeter of blood, while the number for animals fed a breeding diet was 11,000.

6. The spleen of a rat at birth averaged about 0.17 percent of the total body weight. This increased to 0.7 percent of the body weight at 14 days of age. A decrease in size of the organ beyond this age occurred, to 0.3 percent of the body weight at 67 days of age.

7. The spleen of a rat at birth was found histologically to be composed largely of erythropoietic tissue. The erythropoietic tissue increased in quantity with increase in absolute size and proportionate size of the organ, being greatest at 14 days of age. The tissue began to disappear beyond this age, having almost completely disappeared at 35 days of age in animals that had received the breeding diet. The disappearance of the

erythropoietic tissue occurred more slowly in animals receiving the milk diet, remnants being present as late as 70 days of age.

8. The lymphoid tissue of the spleen was present as a few scattered lymphocytes at the time of birth, the cells being periarterial in position. This tissue increased in size after birth, reaching normal adult proportions at 35 days of age. The increase of lymphoid tissue occurred through proliferation and differentiation of reticulo-endothelial cells of the organ. (Hamre)

RODENT CONTROL

Poison Bait Studies

Toxic Agent

Previous acceptance and efficiency tests have indicated that thallium sulphate is the most effective toxic agent for baits for rodent control. During the past year it has been used almost exclusively in the station's rat abatement program in the fields. However, as thallium is also highly toxic to children and animals, the use of this poison around houses and barns has been deemed dangerous, and a substitute was sought. Red squill is a poison specific to rats, and tests have demonstrated that it is efficient for use in the city and also in rural areas around the habitats of man.

Poison Bait Attractants

For many years fresh meats and grains have been the major constituents of poison baits. It has been noted, however, that a bait which gave satisfactory results at one time might lose its appeal, presumably due to changes in food preferences of the rats or availability of more desirable sustenance. Tests indicated that incorporation of attractants with distinctive tastes or odors increased the acceptance of a bait. These attractants included coconut, anise oil, bacon-rind oil, blood, molasses, and peanut butter.

Laboratory grain preference tests were also conducted, using rolled oats, rolled wheat, and cracked potted barley. The barley was by far the least acceptable of the grains, with the oats only slightly preferred to the wheat. The use of dyes to determine the value of coloring grain baits demonstrated that in the laboratory red was more effective than green or blue. This color preference was not duplicated in field tests, however.

Another method of maintaining the efficiency of baiting has been the establishment of a bait rotation schedule. Eight bait formulas were devised, four sausages and four torpedoes being used alternately. The length of time between changing coverages depended on the size and type of infested area and the degree of infestation. Application of a new formula every 2 months appeared satisfactory for densely covered fields harboring about 50 rats per acre.

Luring rats to poisoned baits by pre-baiting appeared to offer some advantages. Bait stations with fresh grain were established, and when a number of rats had been attracted poison was included in the formula.

Rat populations in heavily infested areas were considerably reduced in this manner.

Preservation of Baits

An important problem in poison baiting is to ensure that the bait is fresh and does not develop molds or become unattractive because of insect depredations. Sterilizing of baits by cooking in the laboratory appeared to reduce their acceptability. Vacuum packing made it possible to prepare and hold baits without loss of effectiveness. The use of sodium sulphite as a preservative also was satisfactory, and prevented the development of molds after the baits were broadcast in the field. Oil of citronella in a 1-percent solution was the only insect repellent which did not decrease the attractiveness of baits to the rats.

TRAP STUDIES

Trap Efficiency

Trapping tests demonstrated that failure of many rat-control programs with snap traps was due to an insufficient number of traps and rapid reinfestation from contiguous areas. The number of traps required depends largely on the degree of infestation, and can be determined only by experiment. If the number of rats caught per 100 trap-days does not decrease from week to week, it may be assumed that more traps are necessary. Reinfestation can be prevented, to some extent, by encircling the boundaries of the area with traps stationed at smaller intervals than normal.

Two other factors in the failure of trapping programs appeared to be correlated: Snapping of traps by mice, and time of trap visitation. In general, traps were visited early each morning, captured rats removed, and the traps reset. Mice are not a serious menace to health and to agriculture in the Territory. However, they are creatures of diurnal habit, and traps set early in the morning are often sprung by mice. By night, the most important rat-trapping period, as many as 40 percent of the traps have been rendered inefficient.

Size of Snap Trap

The official snap trap which has been in use by the Bureau of Biological Survey, U. S. Department of Agriculture, is approximately 3 by 7 inches in size. The question was raised whether the high percentage of traps sprung with no catch in a rat-control program on Kauai might be due to insufficiently large traps for the 10- to 16-ounce rats prevalent on that island.

A slightly larger trap, 4 by 8 inches in size with an extra bar across the death-dealing frame to catch mice and small rats, was designed, and 24 such traps were compared with standard sized traps in an efficiency test. The official traps produced an average catch of 32 rats per 100 trap-days, as compared with only 17 for the larger traps. Moreover, only 18 of the smaller traps were sprung without catches while 32 of the larger traps were rendered ineffectual.

RAT MIGRATION STUDIES

During the second half of the fiscal year the station funds set aside for rat control studies were almost exhausted, and the work was financed by the Bureau of Biological Survey. The chief work carried on was a study of the migratory habits of the rat. On an area of 47 acres of densely covered wasteland, 20 passageways were cleared for trapping operations, and a total of 142 cage traps for catching live rats were distributed. Traps were visited daily, and all rats caught were tagged with a number and released, at the same station or elsewhere according to a plan of operations. During the period of the experiment (about 4 months), a total of 521 rats, or 11 per acre, and 46 mongooses, or 1 per acre, were numbered and released. Of this first trapping, 247 rats and 19 mongooses were retrapped at least once, and 1 rat was retrapped 11 times.

As an indication of the traveling radius of rodents, a summary has been made of all animals retrapped after an interval of only 1 day. Table 23 shows the minimum, maximum, and average distances from trapping station to point of retrapping. (Spencer)

TABLE 23.—One-day-interval travel distances of rodents

Species	Number of rodents retrapped at 1-day intervals	Least distance from trapping station	Greatest distance from trapping station	Average travel distance
		Feet	*Feet*	*Feet*
Hawaiian rat	43	0	800	100
Gray rat	16	0	763	220
Black rat	10	0	1,485	390
Norway rat	3	0	630	300
Mongoose	3	600	3,031	1,627

The mongoose gave evidence of a much greater migratory range than any of the four species of rats present in the Territory, and large rats traveled farther than the smaller animals. Further details of this test will be presented in a station bulletin, which will summarize the rat abatement program.

REPORT OF THE BRANCH STATIONS

Poamoho Farm

Poamoho Farm, acquired September 1, 1937, consists of 30.8 acres, and an additional area of 4.3 acres is leased. This farm, between Wahiawa and Waialua, is typical of much land on the island of Oahu and is already proving its value. A modern irrigation system for both contour and overhead irrigation has been largely completed, and an implement shed and combination greenhouse and plant propagation house have been constructed.

The experimental work at present is largely confined to investigations in the fields of horticulture and agronomy. Following a potato variety, fertilizer, and disease control study on an area of 15 acres, 10 acres were planted to papaya seedlings and 5 acres to grafted macadamia trees. The agronomy division has planted 5 acres to various grasses and legumes to test their adaptability. A taro variety plat has also been started.

Kona Branch Station

Material progress has been made in clearing and improving the 7 acres of new land acquired during the past year. Experiments with macadamia, citrus, avocado, mango, taro, and pasture grasses are planned for this area. Coffee investigations, both on the station grounds and in orchards of cooperators, have consumed a large proportion of the time of the superintendent and laborers of the station. Pruning investigations and fertilizer eyperiments are yielding valuable results. Several meetings of farmers and personal visits from interested individuals to the station and the outlying experiments indicate the attention the work is receiving. Macadamia propagation and nursery investigations are also being followed with great interest. During the year, 600 grafted trees of 40 selected varieties of macadamia were grown, packed, and set out in variety tests on Hawaii, Maui, and Oahu; 150 trees each of 40 additional varieties were grafted during the year. Propagations were quite successful, and 1,000 or more grafted trees will be available for transplanting to field tests during 1938-39.

In addition to fruit and nut investigations, the superintendent has supervised agronomy and truck crop field trials set out in Kona, Kamuela, and Kohala.

HALEAKALA BRANCH STATION

This branch station, at an elevation of 2,180 feet on the slopes of Haleakala, has an area of 38.66 acres, crossed by a large gulch. The area to the west of the gulch is being prepared for grazing trials with various grass mixtures. On the east portion, which includes the building site, numerous forage and vegetable trials are being conducted in carefully planned plats with proper repetitions. A small area is also devoted to macadamia variety trials and other fruit trees.

The barn has been enlarged by a 20-by-25-foot extension, and repairs have been made to the superintendent's residence. Other buildings have received a coat of stain. Many fences have been built, the posts being secured from trees grown along the borders of the station and on the side of the gulch.

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(Pierson)

FISCAL STATEMENT — 1937-1938

RECEIPTS

	Regular federal funds	Federal Funds — Agricultural Adjustment Administration						
		Taro	Liver fluke	Rat abatement	Truck crops	Feeds	Fruits and nuts	Poultry
Received from the Treasury of the United States	$ 2,066.00							
Received from the Federal Bureau of Public Roads	360.00							
Balance from 1936-37		$ 5,694.59	$12,021.83	$ 5,114.91	$11,075.64	$25,523.48	$ 9,649.94	$12,639.15
Receipts from Territorial funds								
Receipts from sales								
Total receipts	$ 2,426.00	$ 5,694.59	$12,021.83	$ 5,114.91	$11,075.64	$25,523.48	$ 9,649.94	$12,639.15

DISBURSEMENTS

	Regular federal funds	Taro	Liver fluke	Rat abatement	Truck crops	Feeds	Fruits and nuts	Poultry
Personal services	$ 1.748.10	$ 5,022.30	$ 9,312.31	$ 3,184.85	$ 8,236.74	$16,602.81	$ 7,874.44	$ 8,042.45
Supplies and materials	213.82	175.64	506.80	942.65	841.20	3,951.38	695.40	2,925.95
Communication service	92.60	34.50	3.00	94.10				
Travel expenses		56.70	17.00	330.00	265.40	155.62		
Transportation of things	43.46	36.86		188.92	8.42	116.09	23.81	60.00
Printing and publications					448.10			
Heat, light, water, and power	317.27	15.71	21.00	32.84			82.72	
Rents		87.50	200.00	162.50		670.00		
Contingent expenses		103.20	120.00	72.23	74.73	163.08	42.65	162.65
Equipment	4.75		102.55	106.82	217.20	344.88	168.27	345.34
Buildings and land						229.59		
Washington expenditures	6.00	162.18	252.66		29.79	507.94		299.84
Unexpended balance			1,486.51		954.06	2,782.09	762.65	802.92
Total disbursements	$ 2,426.00	$ 5,694.59	$12,021.83	$ 5,114.91	$11,075.64	$25,523.48	$ 9,649.94	$12,639.15

FISCAL STATEMENT — 1937-1938 (Continued)

RECEIPTS

	Federal Acts				Territorial			Donated	Total
	Hatch	Adams	Purnell	Bankhead-Jones	Bankhead-Jones offset	Special	Coffee	Rat abatement	
Received from the Treasury of the United States	$15,000.00	$15,000.00	$20,000.00	$6,889.80					$ 58,955.80
Received from the Federal Bureau of Public Roads									360.00
Balance from 1936-37								$2,119.52	83,839.06
Receipts from Territorial funds					$6,889.80	$36,906.84	$2,500.00		46,296.64
Receipts from sales						16,372.26		1,518.99	17,891.25
Total receipts	$15,000.00	$15,000.00	$20,000.00	$6,889.80	$6,889.80	$53,279.10	$2,500.00	$3,638.51	$207,342.75

DISBURSEMENTS

	Hatch	Adams	Purnell	Bankhead-Jones	Bankhead-Jones offset	Special	Coffee	Rat abatement	Total
Personal services	$11,917.37	$13,588.21	$18,002.24	$4,572.60	$4,190.25	$22,184.79	$1,350.00	$1,962.50	$137,791.96
Supplies and materials	891.64	1,145.74	921.01	654.41	672.02	9,051.93	65.13	973.24	24,627.96
Communication service					94.05	433.01			751.26
Travel expenses	125.00	33.90	182.40	1.60		1,127.67	172.45	42.00	2,509.74
Transportation of things	35.00	4.53	2.65	.25	11.72	393.38	4.73	10.53	940.35
Printing and publications	927.39					788.34			2,163.83
Heat, light, water, and power			4.85		17.15	2,765.02		34.22	3,290.78
Rents			100.00					452.50	1,672.50
Contingent expenses		14.80		10.50	337.91	4,460.91	.50	102.82	5,665.98
Equipment	1,103.60	212.82	786.85	1,205.70	35.84	2,285.62	203.18	60.70	7,184.12
Buildings and land				444.74	1,530.86	9,788.43			11,993.62
Washington expenditures									1,258.41
Unexpended balance							704.01		7,492.24
Total disbursements	$15,000.00	$15,000.00	$20,000.00	$6,889.80	6,889.80	$53,279.10	$2,500.00	$3,638.51	$207,342.75